Operations and Productivity

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Operations Management, Global Edition, Eleventh Edition
Principles of Operations Management, Global Edition, Ninth Edition

PowerPoint slides by Abhijit Dey

Outline

- Global Company Profile: Hard Rock Cafe
- What Is Operations Management?
- Organizing to Produce Goods and Services
- The Supply Chain
- Why Study OM?
- What Operations Managers Do

Outline - Continued

- The Heritage of Operations Management
- Operations for Goods and Services
  - Growth of Services
  - Service Pay
- The Productivity Challenge
  - Productivity Measurement
  - Productivity Variables
  - Productivity and the Service Sector

Outline - Continued

- New Challenges in Operations Management
- Ethics, Social Responsibility, and Sustainability

Learning Objectives

When you complete this chapter you should be able to:

1. **Define** operations management
2. **Explain** the distinction between goods and services
3. **Explain** the difference between production and productivity

Learning Objectives

When you complete this chapter you should be able to:

4. **Compute** single-factor productivity
5. **Compute** multifactor productivity
6. **Identify** the critical variables in enhancing productivity

Operations Management at Hard Rock Cafe

- First opened in 1971
  - Now – 150 restaurants in over 53 countries
- Rock music memorabilia
- Creates value in the form of good food and entertainment
- 3,500^{+} custom meals per day in Orlando
- How does an item get on the menu?
- Role of the Operations Manager

What Is Operations Management?

Production is the creation of goods and services

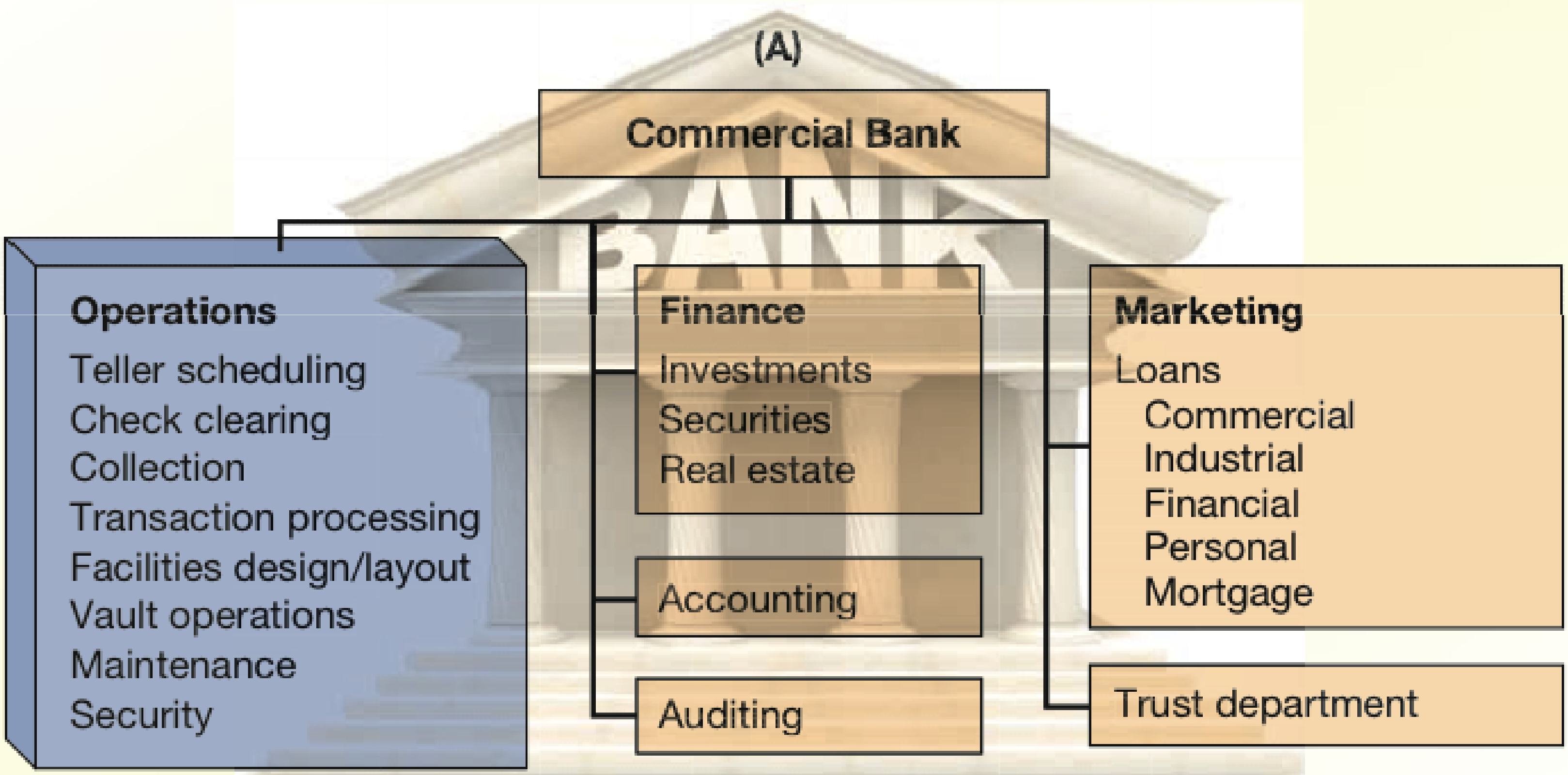
Operations management (OM) is the set of activities that create value in the form of goods and services by transforming inputs into outputs

Organizing to Produce Goods and Services

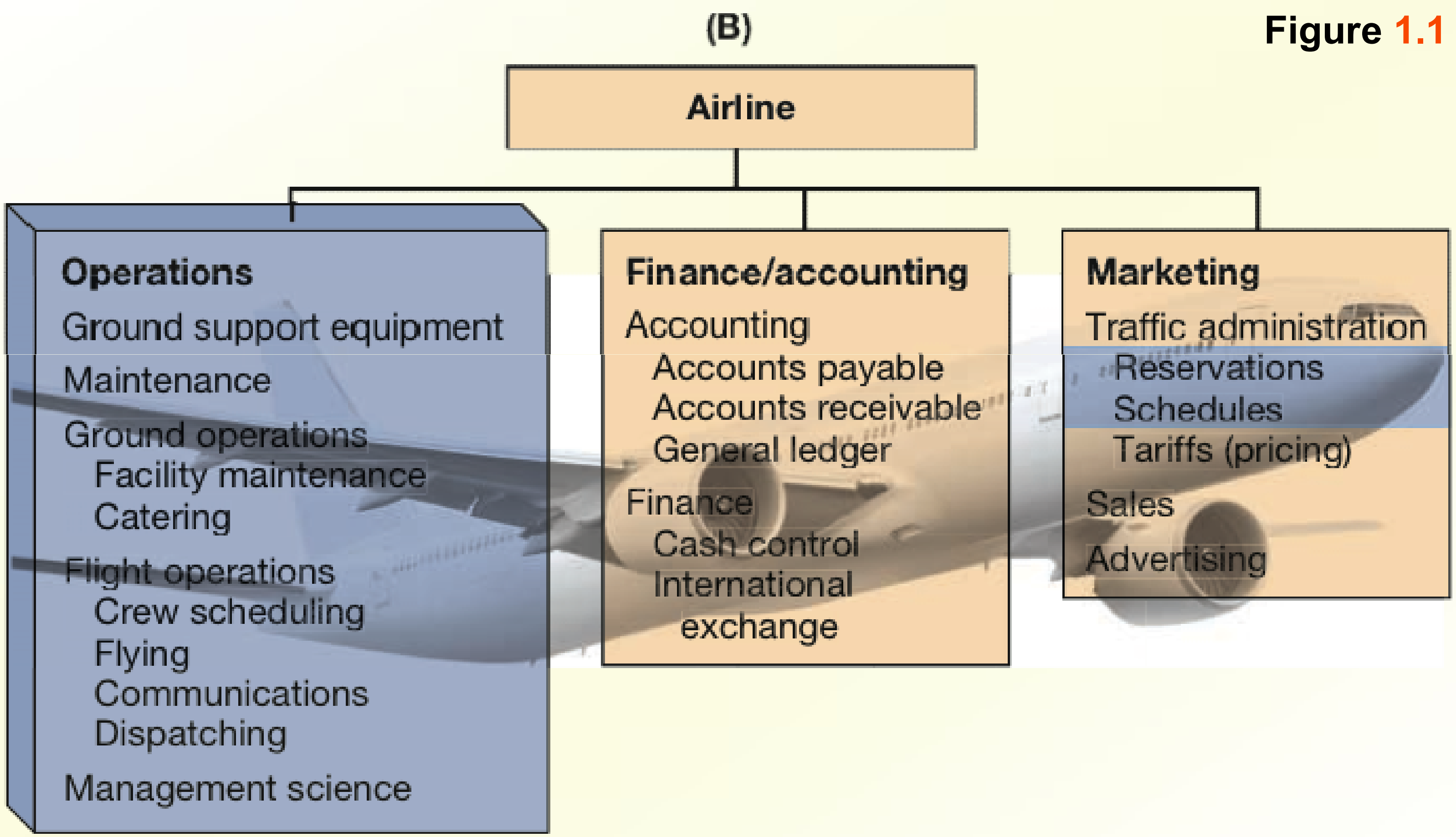
- Essential functions:
  1. **Marketing** – generates demand
  2. **Production/operations** – creates the product
  3. **Finance/accounting** – tracks how well the organization is doing, pays bills, collects the money

Organizational Charts

Figure 1.1



Organizational Charts



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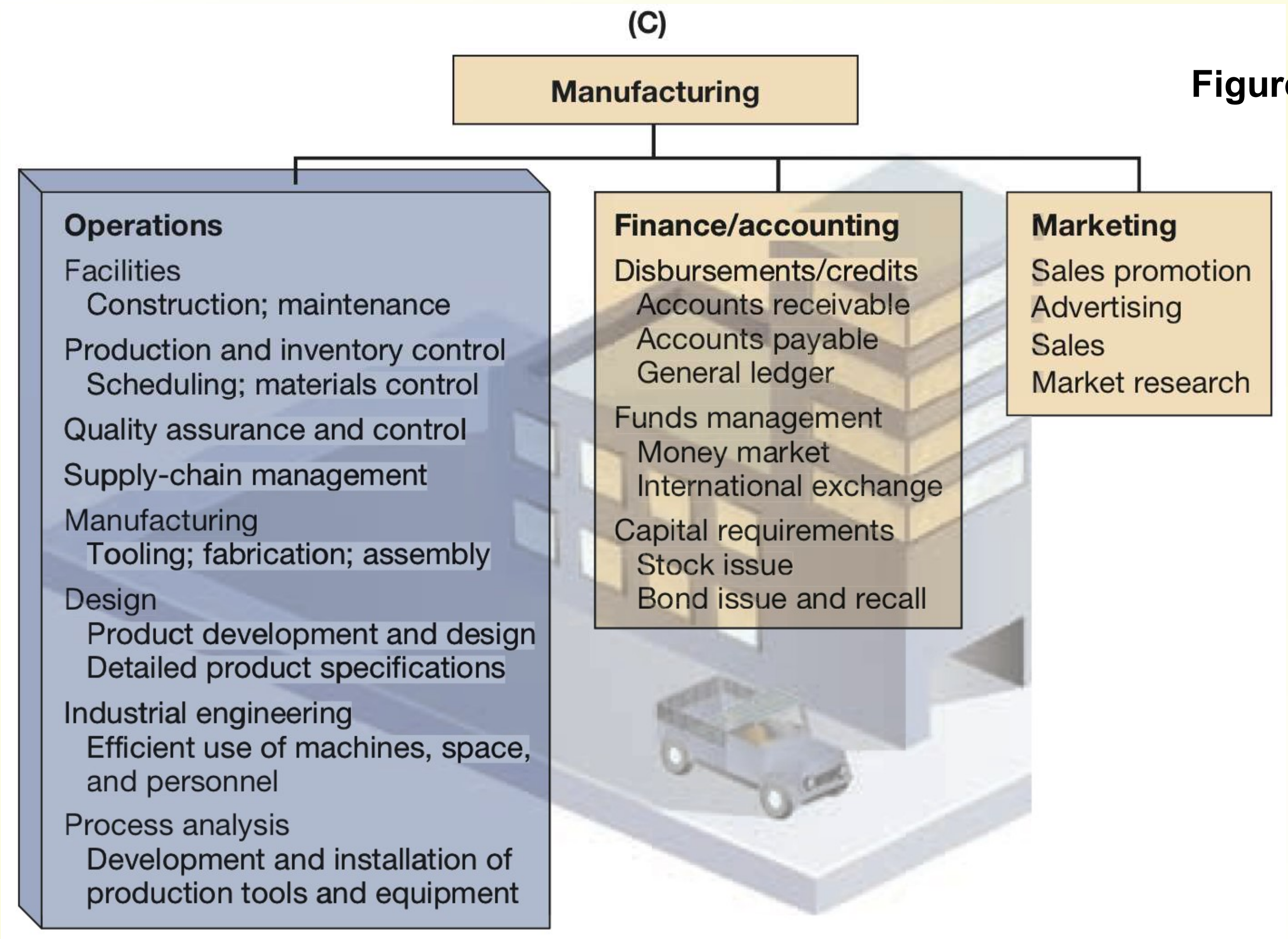
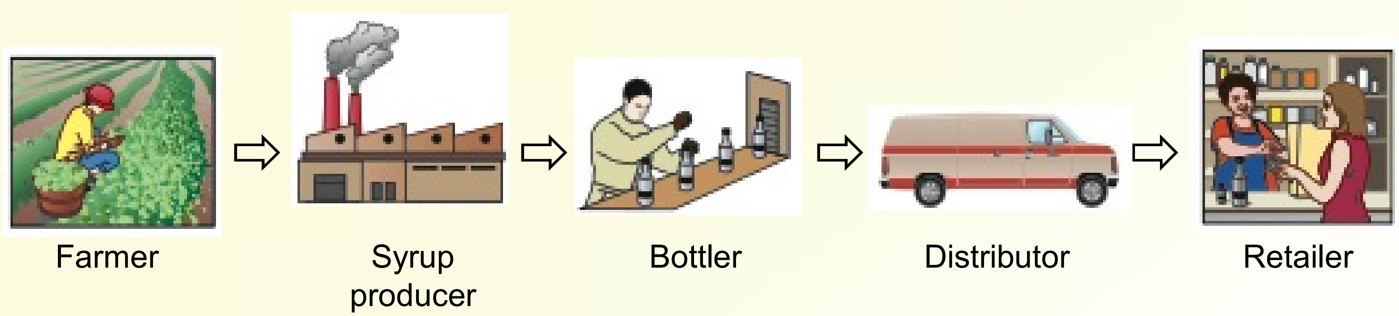


Figure 1.1

The Supply Chain

- A global network of organizations and activities that supply a firm with goods and services
- Members of the supply chain collaborate to achieve high levels of customer satisfaction, efficiency and competitive advantage.

Figure 1.2



Why Study OM?

1. OM is one of three major functions of any organization, we want to study how people organize themselves for productive enterprise
2. We want (*and need*) to know how goods and services are produced
3. We want to understand what operations managers do
4. OM is such a costly part of an organization

Options for Increasing Contribution

TABLE 1.1

		MARKETING OPTION	FINANCE /ACCOUNTING OPTION	OM OPTION
	CURRENT	INCREASE SALES REVENUE 50%	REDUCE FINANCE COSTS 50%	REDUCE PRODUCTION COSTS 20%
Sales	$100,000	$150,000	$100,000	$100,000
Cost of goods	–80,000	–120,000	–80,000	–64,000
Gross margin	20,000	30,000	20,000	36,000
Finance costs	–6,000	–6,000	–3,000	–6,000
Subtotal	14,000	24,000	17,000	30,000
Taxes at 25%	–3,500	–6,000	–4,200	–7,500
Contribution	$ 10,500	$ 18,000	$ 12,750	$ 22,500

What Operations Managers Do

Basic Management Functions

- Planning
- Organizing
- Staffing
- Leading
- Controlling

Ten Strategic Decisions

TABLE 1.2

DECISION	CHAPTER(S)
1. Design of goods and services	5, Supplement 5
2. Managing quality	6, Supplement 6
3. Process and capacity design	7, Supplement 7
4. Location strategy	8
5. Layout strategy	9
6. Human resources and job design	10
7. Supply-chain management	11, Supplement 11
8. Inventory management	12, 14, 16
9. Scheduling	13, 15
10. Maintenance	17

The Strategic Decisions

1. **Design of goods and services**
   - Defines what is required of operations
   - Product design determines quality, sustainability and human resources
2. **Managing quality**
   - Determine the customer's quality expectations
   - Establish policies and procedures to identify and achieve that quality

Table 1.2 (cont.)

The Strategic Decisions

3. **Process and capacity design**
    - How is a good or service produced?
    - Commits management to specific technology, quality, resources, and investment.
4. **Location strategy**
    - Nearness to customers, suppliers, and talent.
    - Considering costs, infrastructure, logistics, and government.

Table 1.2 (cont.)

The Strategic Decisions

5. **Layout strategy**
   - Integrate capacity needs, personnel levels, technology, and inventory
   - Determine the efficient flow of materials, people, and information.
6. **Human resources and job design**
   - Recruit, motivate, and retain personnel with the required talent and skills.
   - Integral and expensive part of the total system design.

Table 1.2 (cont.)

The Strategic Decisions

7. **Supply-chain management**
   - Integrate supply chain into the firm's strategy.
   - Determine what is to be purchased, from whom, and under what conditions.
8. **Inventory management**
   - Inventory ordering and holding decisions.
   - Optimize considering customer satisfaction, supplier capability, and production schedules.

Table 1.2 (cont.)

The Strategic Decisions

9. **Scheduling**
   - Determine and implement intermediate- and short-term schedules.
   - Utilize personnel and facilities while meeting customer demands.
10. **Maintenance**
    - Consider facility capacity, production demands, and personnel.
    - Maintain a reliable and stable process.

Table 1.2 (cont.)

Where are the OM Jobs?

- Technology/methods
- Facilities/space utilization
- Strategic issues
- Response time
- People/team development
- Customer service
- Quality
- Cost reduction
- Inventory reduction
- Productivity improvement

Opportunities

Figure 1.3

Operations Management Positions

SEARCH JOBS

Date | Job Title

1/15 **Plant Manager**

Division of Fortune 1000 company seeks plant manager for plant located in the upper Hudson Valley area. This plant manufactures loading dock equipment for commercial markets. The candidate must be experienced in plant management including expertise in production planning, purchasing, and inventory management. Good written and oral communication skills are a must, along with excellent application of skills in managing people.

2/23 **Operations Analyst**

Expanding national coffee shop: top 10 “Best Places to Work” wants junior level systems analyst to join our excellent store improvement team. Business or I.E. degree, work methods, labor standards, ergonomics, cost accounting knowledge a plus. This is a hands-on job and excellent opportunity for a team player with good people skills. West coast location. Some travel required.

3/18 **Quality Manager**

Several openings exist in our small package processing facilities in the Northeast, Florida, and Southern California for quality managers. These highly visible positions require extensive use of statistical tools to monitor all aspects of service, timeliness, and workload measurement. The work involves (1) a combination of hands-on applications and detailed analysis using databases and spreadsheets, (2) process audits to identify areas for improvement and (3) management of implementation of changes. Positions involve night hours and weekends.

4/6 **Supply-Chain Manager and Planner**

Responsibilities entail negotiating contracts and establishing long-term relationships with suppliers. We will rely on the selected candidate to maintain accuracy in the purchasing system, invoices, and product returns. A bachelor's degree and up to 2 years related experience are required. Working knowledge of MRP, ability to use feedback to master scheduling and suppliers and consolidate orders for best price and delivery are necessary. Proficiency in all PC Windows applications, particularly Excel and Word, is essential. Effective verbal and written communication skills are essential.

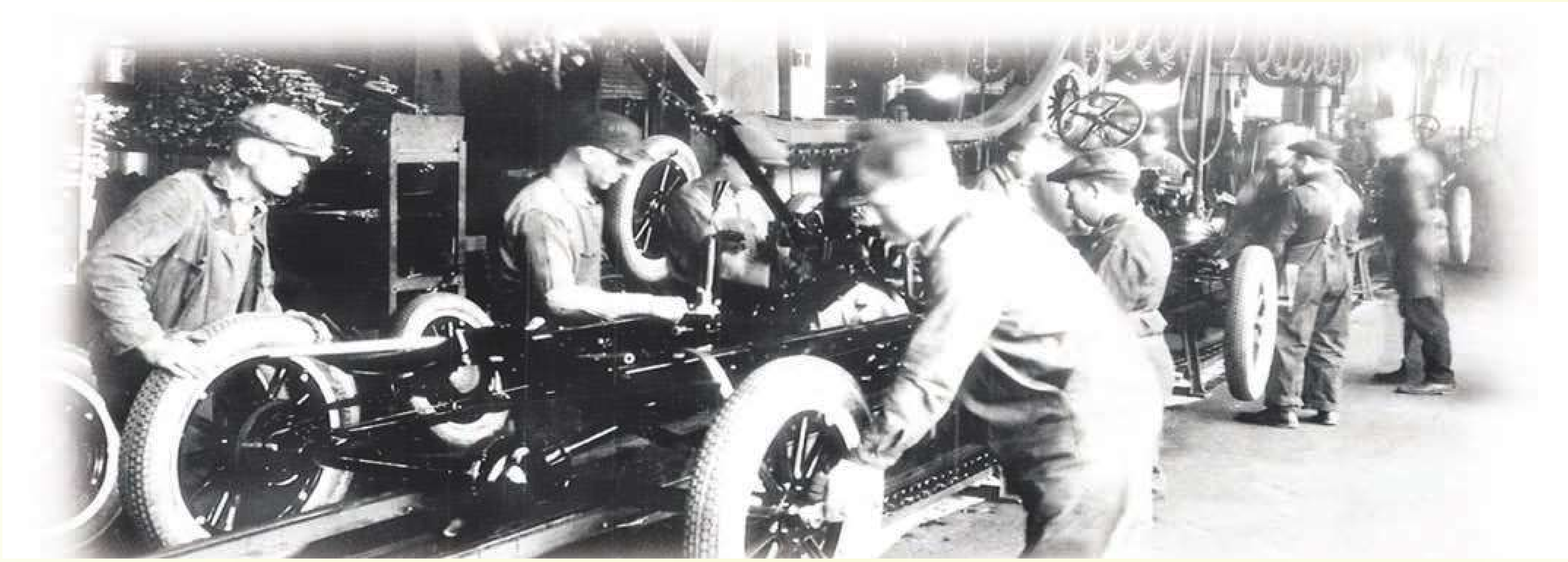
5/14 **Process Improvement Consultants**

An expanding consulting firm is seeking consultants to design and implement lean production and cycle time reduction plans in both service and manufacturing processes. Our firm is currently working with an international bank to improve its back office operations, as well as with several manufacturing firms. A business degree required; APICS certification a plus.

Certifications

- APICS, the Association for Operations Management
- American Society for Quality (ASQ)
- Institute for Supply Management (ISM)
- Project Management Institute (PMI)
- Council of Supply Chain Management Professionals
- Charter Institute of Purchasing and Supply (CIPS)

Significant Events in OM



Cost Focus		Quality Focus	Customization Focus	Globalization Focus
Early Concepts 1776–1880 Labor Specialization (Smith, Babbage) Standardized Parts (Whitney) **Scientific Management Era 1880–1910** Gantt Charts (Gantt) Motion & Time Studies (Gilbreth) Process Analysis (Taylor) Queuing Theory (Erlang)	**Mass Production Era 1910–1980** Moving Assembly Line (Ford/Sorensen) Statistical Sampling (Shewhart) Economic Order Quantity (Harris) Linear Programming PERT/CPM (DuPont) Material Requirements Planning (MRP)	**Lean Production Era 1980–1995** Just-in-Time (JIT) Computer-Aided Design (CAD) Electronic Data Interchange (EDI) Total Quality Management (TQM) Baldrige Award Empowerment Kanbans	**Mass Customization Era 1995–2005** Internet/E-Commerce Enterprise Resource Planning International Quality Standards (ISO) Finite Scheduling Supply Chain Management Mass Customization Build-to-Order	**Globalization Era 2005–2020** Global Supply Chains Growth of Transnational Organizations Instant Communications Sustainability Ethics in a Global Workforce Logistics

Figure 1.4

The Heritage of OM

- Division of labor (Adam Smith 1776; Charles Babbage 1852)
- Standardized parts (Whitney 1800)
- Scientific Management (Taylor 1881)
- Coordinated assembly line (Ford/ Sorenson 1913)
- Gantt charts (Gantt 1916)
- Motion study (Frank and Lillian Gilbreth 1922)
- Quality control (Shewhart 1924; Deming 1950)

The Heritage of OM

- Computer (Atanasoff 1938)
- CPM/PERT (DuPont 1957, Navy 1958)
- Material requirements planning (Orlicky 1960)
- Computer aided design (CAD 1970)
- Flexible manufacturing system (FMS 1975)
- Baldrige Quality Awards (1980)
- Computer integrated manufacturing (1990)
- Globalization (1992)
- Internet (1995)

Eli Whitney

- Born 1765; died 1825
- In 1798, received government contract to make 10,000 muskets
- Showed that machine tools could make standardized parts to exact specifications
  - Musket parts could be used in any musket

Frederick W. Taylor

- Born 1856; died 1915
- Known as ‘father of scientific management’
- In 1881, as chief engineer for Midvale Steel, studied how tasks were done
  - Began first motion and time studies
- Created efficiency principles

Taylor's Principles

Management Should Take More Responsibility for:

- Matching employees to right job
- Providing the proper training
- Providing proper work methods and tools
- Establishing legitimate incentives for work to be accomplished

Frank & Lillian Gilbreth

- Frank (1868-1924); Lillian (1878-1972)
- Husband-and-wife engineering team
- Further developed work measurement methods
- Applied efficiency methods to their home and 12 children!
- Book & Movie: “Cheaper by the Dozen,” “Bells on Their Toes”

Henry Ford

- Born 1863; died 1947
- In 1903, created Ford Motor Company
- In 1913, first used moving assembly line to make Model T
  - Unfinished product moved by conveyor past work station
- Paid workers very well for 1911 ($5/day!)

W. Edwards Deming

- Born 1900; died 1993
- Engineer and physicist
- Credited with teaching Japan quality control methods in post-WW2
- Used statistics to analyze process
- His methods involve workers in decisions

Contributions From

- Human factors
- Industrial engineering
- Management science
- Biological science
- Physical sciences
- Information technology

Operations for Goods and Services

- Manufacturers produce tangible product, services often intangible
- Operations activities often very similar
- Distinction not always clear
- Few pure services

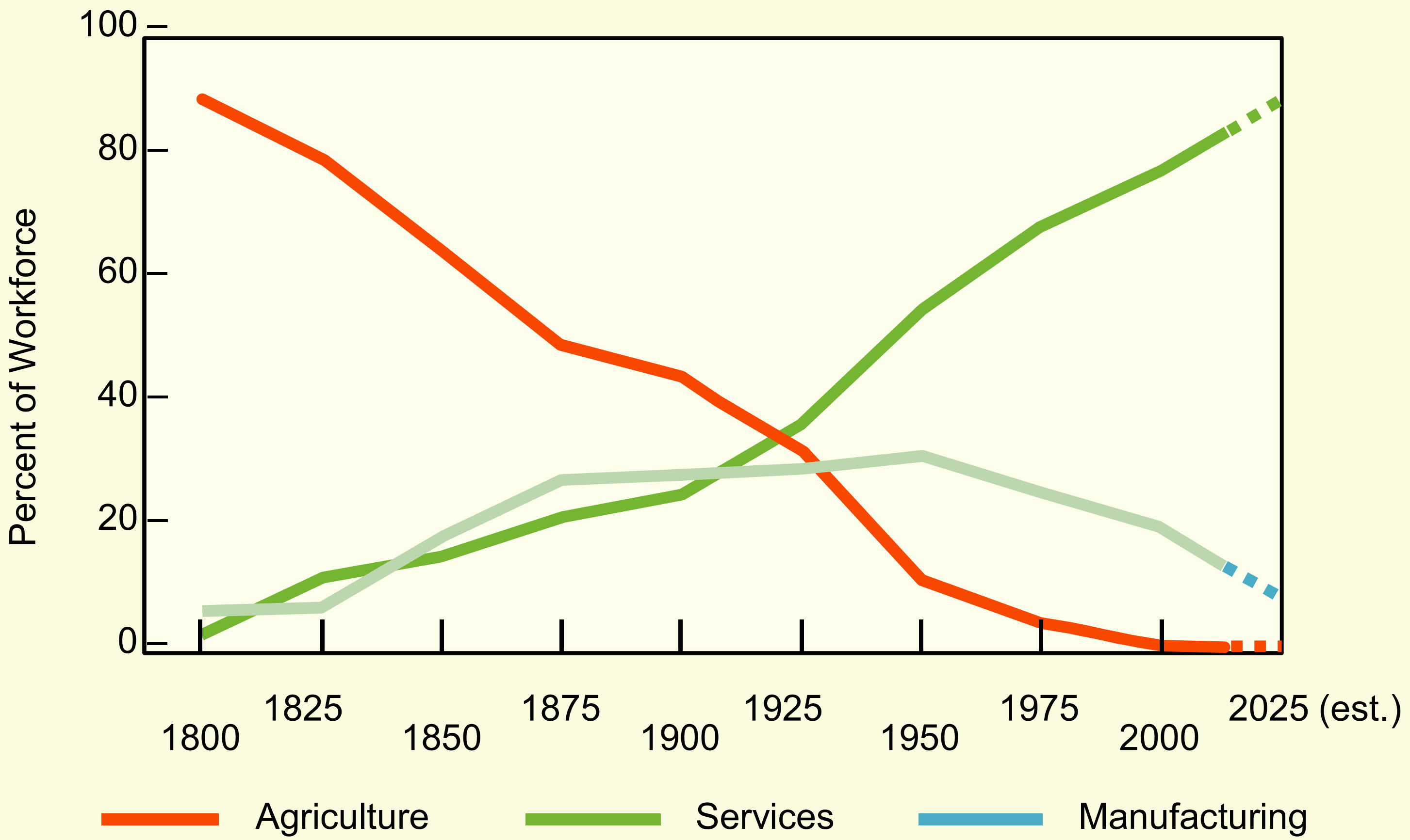
Differences Between Goods and Services

TABLE 1.3

CHARACTERISTICS OF SERVICES	CHARACTERISTICS OF GOODS
Intangible: Ride in an airline seat	Tangible: The seat itself
Produced and consumed simultaneously: Beauty salon produces a haircut that is consumed as it is produced	Product can usually be kept in inventory (beauty care products)
Unique: Your investments and medical care are unique	Similar products produced (iPods)
High customer interaction: Often what the customer is paying for (consulting, education)	Limited customer involvement in production
Inconsistent product definition: Auto Insurance changes with age and type of car	Product standardized (iPhone)
Often knowledge based: Legal, education, and medical services are hard to automate	Standard tangible product tends to make automation feasible
Services dispersed: Service may occur at retail store, local office, house call, or via internet.	Product typically produced at a fixed facility
Quality may be hard to evaluate: Consulting, education, and medical services	Many aspects of quality for tangible products are easy to evaluate (strength of a bolt)
Reselling is unusual: Musical concert or medical care	Product often has some residual value

U.S. Agriculture, Manufacturing, and Service Employment

Figure 1.5



Organizations in Each Sector

TABLE 1.4

SECTOR	EXAMPLE	PERCENT OF ALL JOBS	
Service Sector			
Education, Legal, Medical, Other	San Diego Zoo, Arnold Palmer Hospital	13.2	85.9
Trade (retail, wholesale)	Walgreen's, Walmart, Nordstrom	13.8	
Utilities, Transportation	Pacific Gas & Electric, American Airlines	3.3	
Professional and Business Services	Snelling and Snelling, Waste Management, Inc.	10.1	
Finance, Information, Real Estate	Citicorp, American Express, Prudential, Aetna	21.0	
Food, Lodging, Entertainment	Olive Garden, Motel 6, Walt Disney	9.0	
Public Administration	U.S., State of Alabama, Cook County	15.5	
Manufacturing Sector	General Electric, Ford, U.S. Steel, Intel		8.2
Construction Sector	Bechtel, McDermott		4.1
Agriculture	King Ranch		1.4
Mining Sector	Homestake Mining		.4
Grand Total			100.0

Service Pay

- Perception that services are low-paying
- 42% of service workers receive above average wages
- 14 of 33 service industries pay below average
- Retail trade pays only 61% of national average
- Overall average wage is 96% of the average

Productivity Challenge

Productivity is the ratio of outputs (goods and services) divided by the inputs (resources such as labor and capital)

The objective is to improve productivity!

Important Note!
Production is a measure of output only and not a measure of efficiency

The Economic System

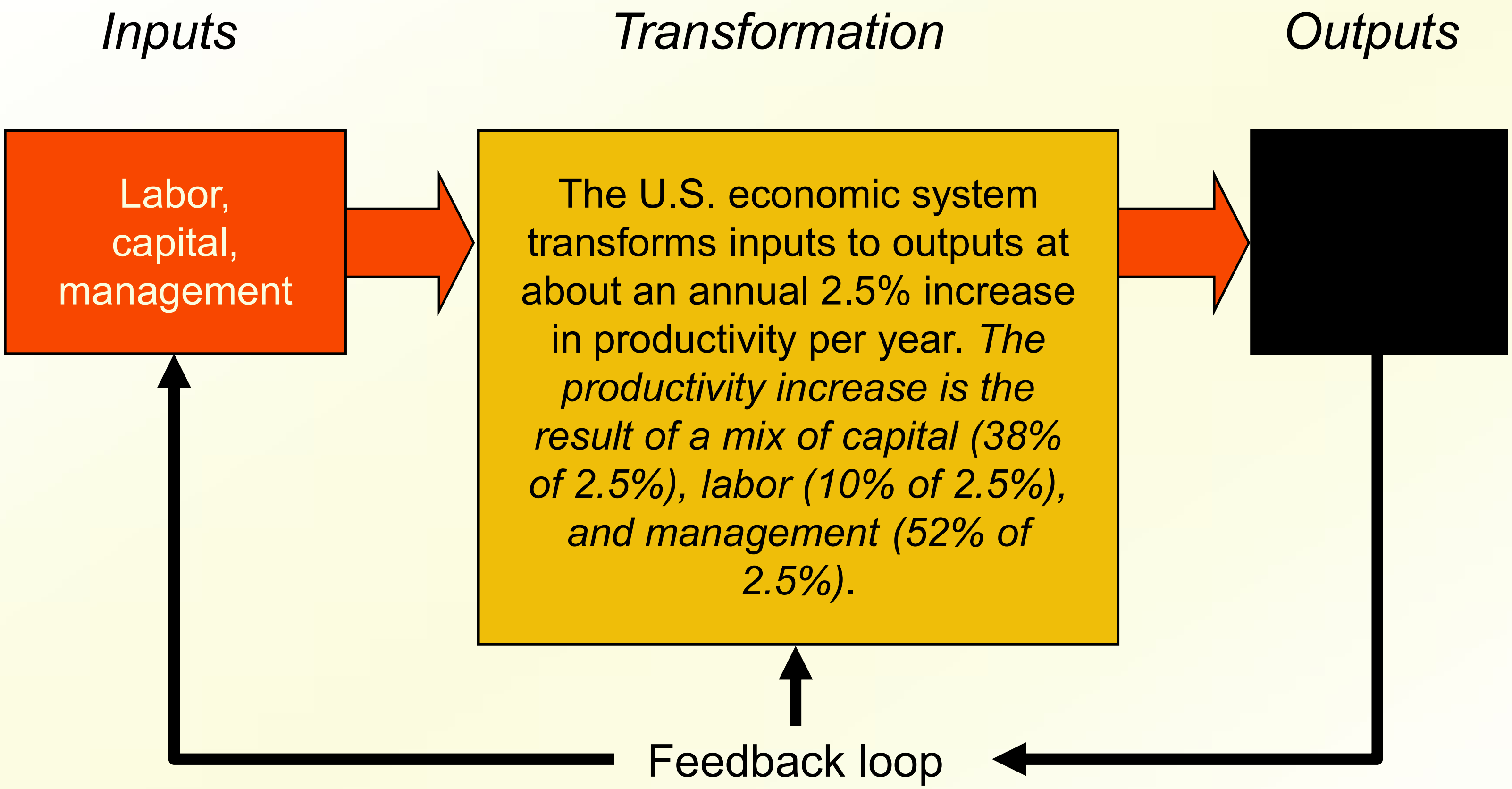


Figure 1.6

Improving Productivity at Starbucks

A team of 10 analysts continually look for ways to shave time. Some improvements:

Stop requiring signatures on credit card purchases under $25	→	Saved 8 seconds per transaction
Change the size of the ice scoop	→	Saved 14 seconds per drink
New espresso machines	→	Saved 12 seconds per shot

Improving Productivity at Starbucks

A team of 10 analysts continually look for ways to shave time. Some improvements:

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Change the size of the ice scoop	➡	Saved 14 seconds per drink
New espresso machines	➡	Saved 12 seconds per shot

Productivity

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Input used}}$$

- Measure of process improvement
- Represents output relative to input
- Only through productivity increases can our standard of living improve

Productivity Calculations

Labor Productivity

$$\text{Productivity} = \frac{\text{Units produced}}{\text{Labor-hours used}}$$

$$= \frac{1{,}000}{250} = 4 \text{ units/labor-hour}$$

One resource input ⇨ single-factor productivity

Multi-Factor Productivity

$$\text{Productivity} = \frac{\text{Output}}{\text{Labor + Material + Energy + Capital + Miscellaneous}}$$

- Also known as total factor productivity
- Output and inputs are often expressed in dollars

Multiple resource inputs ⇨ multi-factor productivity

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day
Payroll cost = $640/day

8 titles/day
Overhead = $400/day

$$\text{Old labor productivity} = \frac{8 \text{ titles/day}}{32 \text{ labor-hrs}}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day — 8 titles/day

Payroll cost = $640/day — Overhead = $400/day

$$\text{Old labor productivity} = \frac{\text{8 titles/day}}{\text{32 labor-hrs}} = \text{.25 titles/labor-hr}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day — 8 titles/day

Payroll cost = $640/day — Overhead = $400/day

New System:

14 titles/day — Overhead = $800/day

$$\text{Old labor productivity} = \frac{8 \text{ titles/day}}{32 \text{ labor-hrs}} = .25 \text{ titles/labor-hr}$$

$$\text{New labor productivity} = \frac{14 \text{ titles/day}}{32 \text{ labor-hrs}}$$

Collins Title Productivity

Old System:

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$$\text{Old labor productivity} = \frac{8 \text{ titles/day}}{32 \text{ labor-hrs}} = .25 \text{ titles/labor-hr}$$

$$\text{New labor productivity} = \frac{14 \text{ titles/day}}{32 \text{ labor-hrs}} = .4375 \text{ titles/labor-hr}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day
Payroll cost = $640/day

8 titles/day
Overhead = $400/day

New System:

14 titles/day

Overhead = $800/day

$$\text{Old multifactor productivity} = \frac{8 \text{ titles/day}}{\$640 + 400}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day 8 titles/day
Payroll cost = $640/day Overhead = $400/day

New System:

14 titles/day Overhead = $800/day

$$\text{Old multifactor productivity} = \frac{8 \text{ titles/day}}{\$640 + 400} = .0077 \text{ titles/dollar}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day — 8 titles/day

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$$\text{New multifactor productivity} = \frac{14 \text{ titles/day}}{\$640 + 800}$$

Collins Title Productivity

Old System:

Staff of 4 works 8 hrs/day 8 titles/day
Payroll cost = $640/day Overhead = $400/day

New System:

14 titles/day Overhead = $800/day

$$\text{Old multifactor productivity} = \frac{8 \text{ titles/day}}{\$640 + 400} = .0077 \text{ titles/dollar}$$

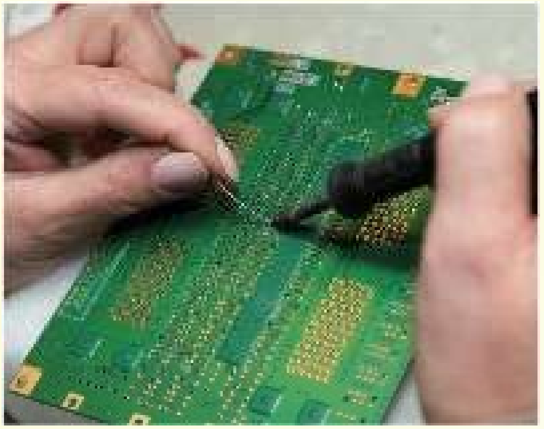
$$\text{New multifactor productivity} = \frac{14 \text{ titles/day}}{\$640 + 800} = .0097 \text{ titles/dollar}$$

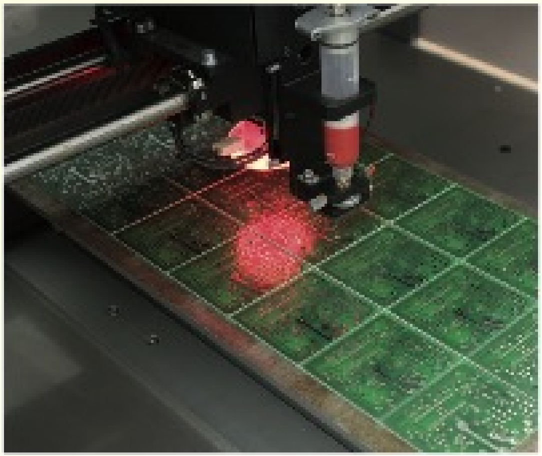
Measurement Problems

1. **Quality** may change while the quantity of inputs and outputs remains constant
2. **External elements** may cause an increase or decrease in productivity
3. **Precise units** of measure may be lacking

Productivity Variables

1. **Labor** - contributes about 10% of the annual increase
2. **Capital** - contributes about 38% of the annual increase
3. **Management** - contributes about 52% of the annual increase





Key Variables for Improved Labor Productivity

1. Basic education appropriate for the labor force
2. Diet of the labor force
3. Social overhead that makes labor available
   - Challenge is in maintaining and enhancing skills in the midst of rapidly changing technology and knowledge

Labor Skills

About half of the 17-year-olds in the U.S. cannot correctly answer questions of this type

6 yds

4 yds

What is the area of this rectangle?

__________ 4 square yds
__________ 6 square yds
__________ 10 square yds
__________ 20 square yds
__________ 24 square yds

If $9y + 3 = 6y + 15$ then $y =$

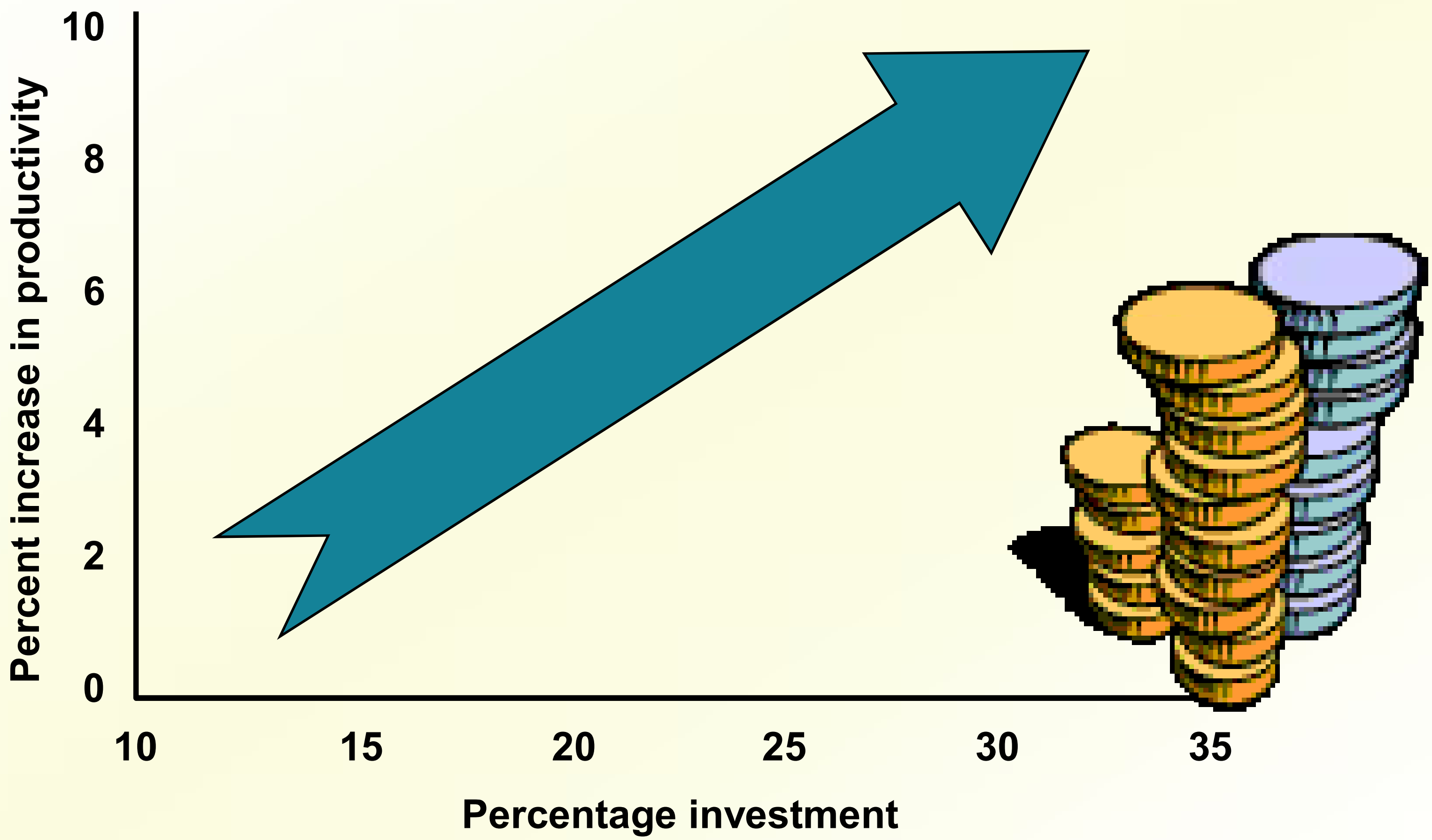
__________ 1 __________ 4
__________ 2 __________ 6

Which of the following is true about 84% of 100?

__________ It is greater than 100
__________ It is less than 100
__________ It is equal to 100

Figure 1.7

Capital



Percent increase in productivity
0
2
4
6
8
10
10
15
20
25
30
35
Percentage investment

Management

- Ensures labor and capital are effectively used to increase productivity
  - Use of knowledge
  - Application of technologies
- Knowledge societies
- Difficult challenge

Productivity and the Service Sector

1. Typically labor intensive
2. Frequently focused on unique individual attributes or desires
3. Often an intellectual task performed by professionals
4. Often difficult to mechanize and automate
5. Often difficult to evaluate for quality

New Challenges in OM

- Global focus
- Supply-chain partnering
- Sustainability
- Rapid product development
- Mass customization
- Just-in-time performance
- Empowered employees

Ethics, Social Responsibility, and Sustainability

Challenges facing operations managers:

- Develop and produce safe, high-quality green products
- Train, retrain, and motivate employees in a safe workplace
- Honor stakeholder commitments

CHAPTER
2

Forecasting

FORECAST:

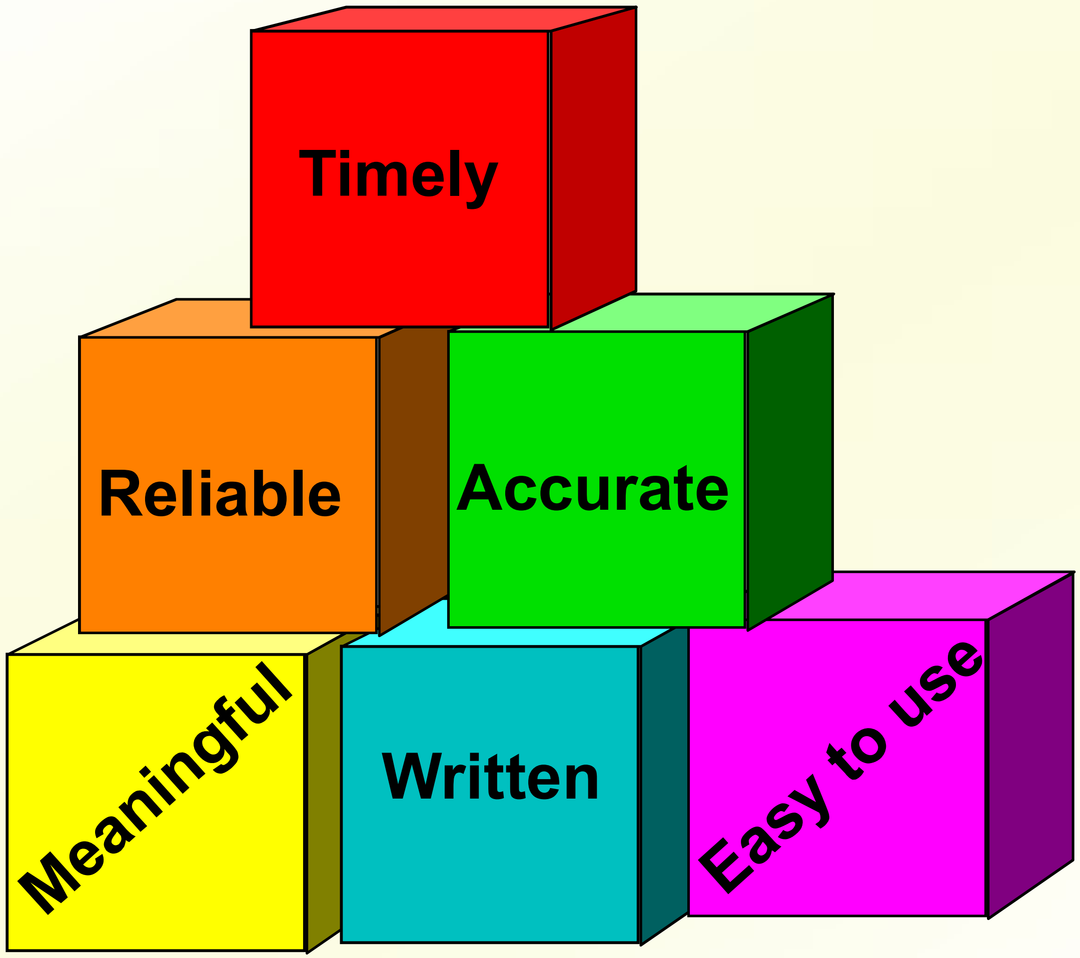
- A statement about the future value of a variable of interest such as demand.
- Forecasts affect decisions and activities throughout an organization
  - Accounting, finance
  - Human resources
  - Marketing
  - MIS
  - Operations
  - Product / service design

Uses of Forecasts

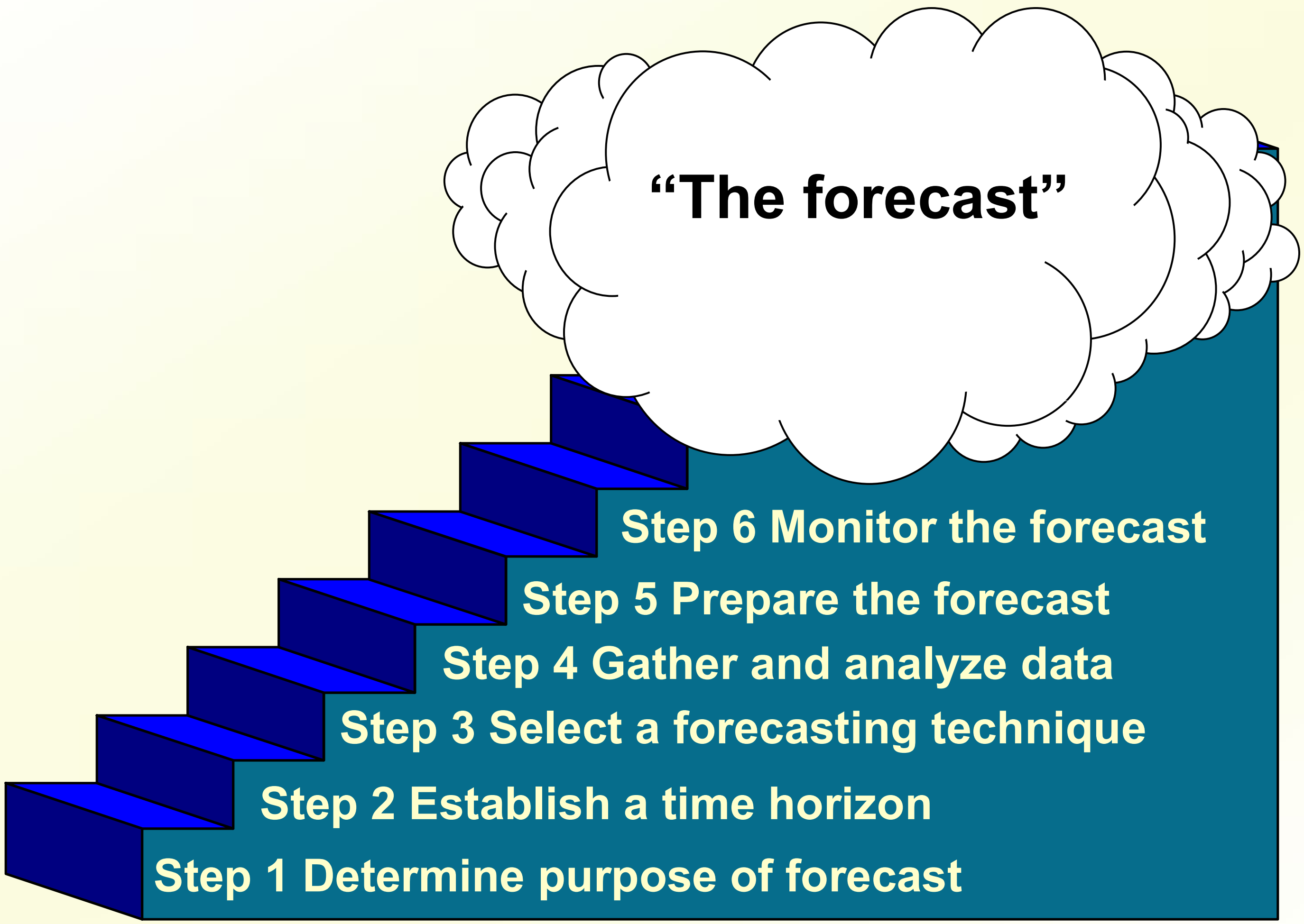
Accounting	Cost/profit estimates
Finance	Cash flow and funding
Human Resources	Hiring/recruiting/training
Marketing	Pricing, promotion, strategy
MIS	IT/IS systems, services
Operations	Schedules, MRP, workloads
Product/service design	New products and services

- Assumes causal system
  past ==> future
- Forecasts rarely perfect because of randomness
- Forecasts more accurate for groups vs. individuals
- Forecast accuracy decreases as time horizon increases

Elements of a Good Forecast



Steps in the Forecasting Process



Types of Forecasts

- *Judgmental* - uses subjective inputs
- *Time series* - uses historical data assuming the future will be like the past
- *Associative models* - uses explanatory variables to predict the future

Judgmental Forecasts

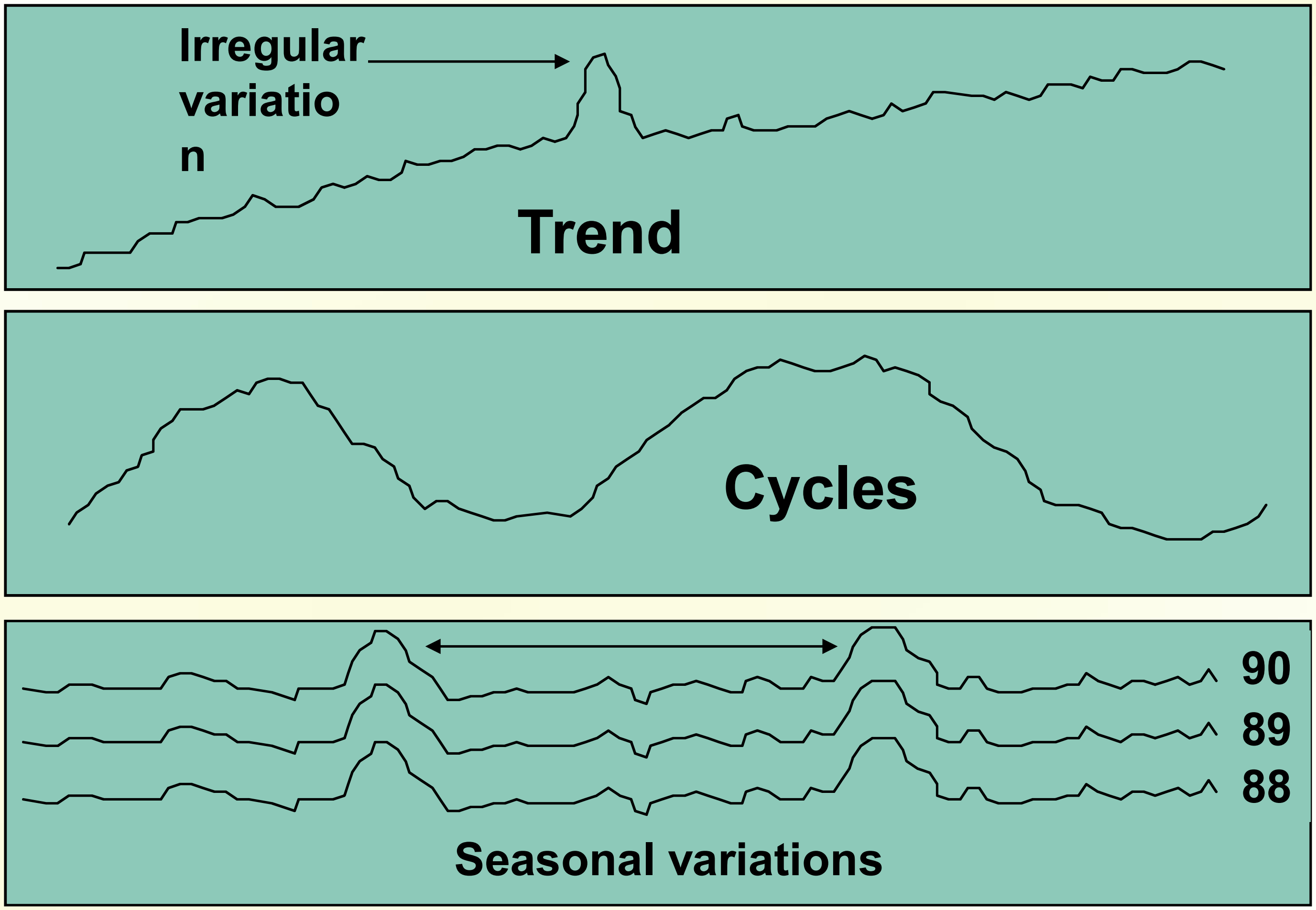
- Executive opinions
- Sales force opinions
- Consumer surveys
- Outside opinion
- Delphi method
  - Opinions of managers and staff
  - Achieves a consensus forecast

Time Series Forecasts

- *Trend* - long-term movement in data
- *Seasonality* - short-term regular variations in data
- Cycle – wavelike variations of more than one year's duration
- *Irregular variations* - caused by unusual circumstances
- *Random variations* - caused by chance

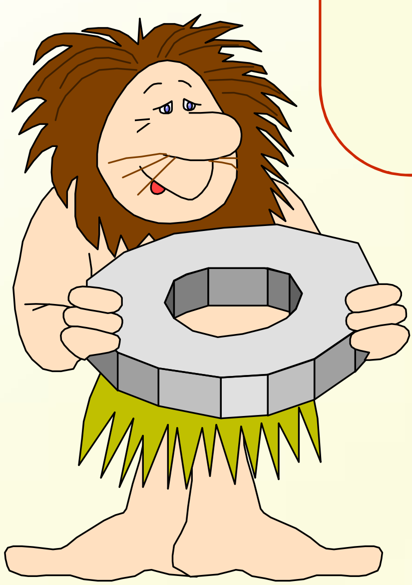
Forecast Variations

Figure 3.1



Naive Forecasts

Uh, give me a minute.... We sold 250 wheels last week.... Now, next week we should sell....



The forecast for any period equals the previous period's actual value.

Naïve Forecasts

- Simple to use
- Virtually no cost
- Quick and easy to prepare
- Data analysis is nonexistent
- Easily understandable
- Cannot provide high accuracy
- Can be a standard for accuracy

Techniques for Averaging

- Moving average
- Weighted moving average
- Exponential smoothing

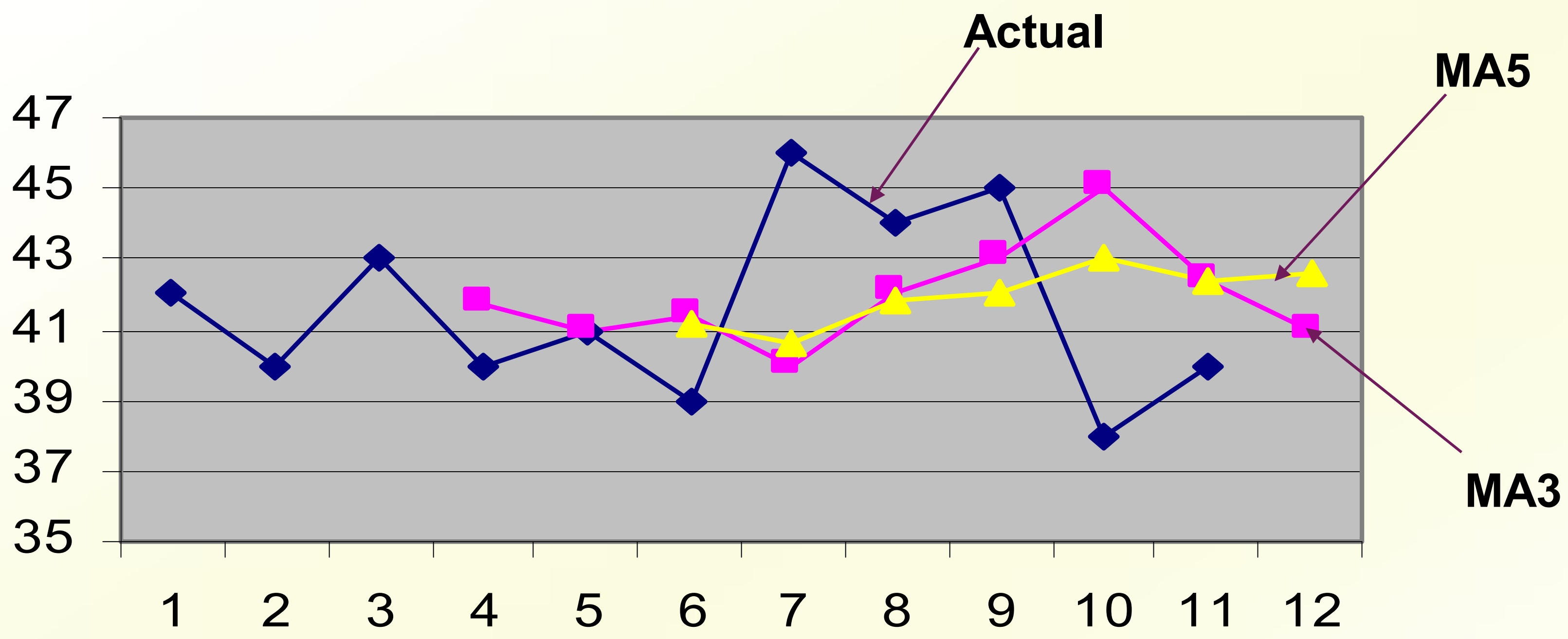
Moving Averages

- *Moving average* – A technique that averages a number of recent actual values, updated as new values become available.

$$MA_n = \frac{\sum_{i=1}^{n} A_i}{n}$$

- *Weighted moving average* – More recent values in a series are given more weight in computing the forecast.

Simple Moving Average



$$MA_n = \frac{\sum_{i=1}^{n} A_i}{n}$$

Exponential Smoothing

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

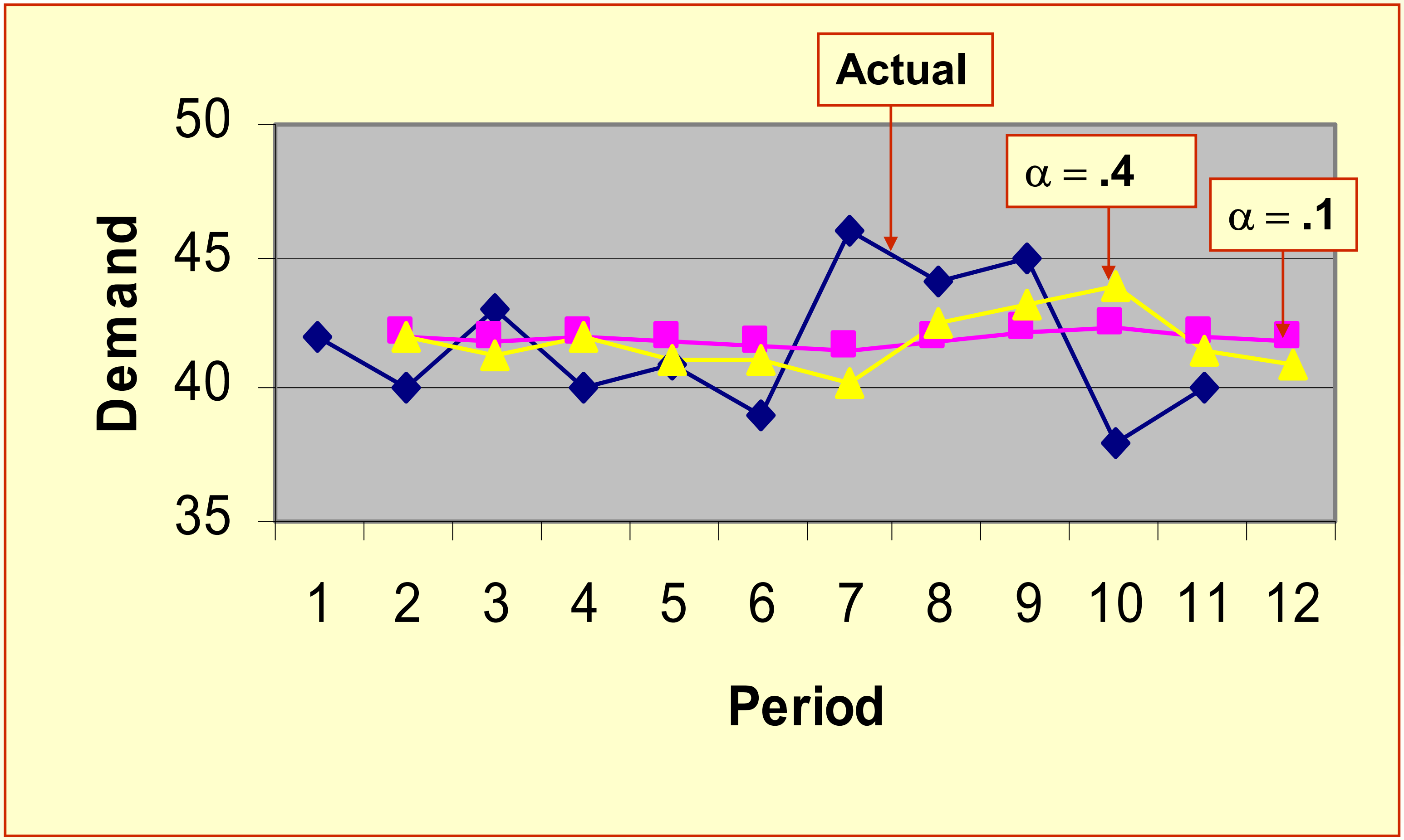
- *Premise*--The most recent observations might have the highest predictive value.
  - Therefore, we should give more weight to the more recent time periods when forecasting.

Exponential Smoothing

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

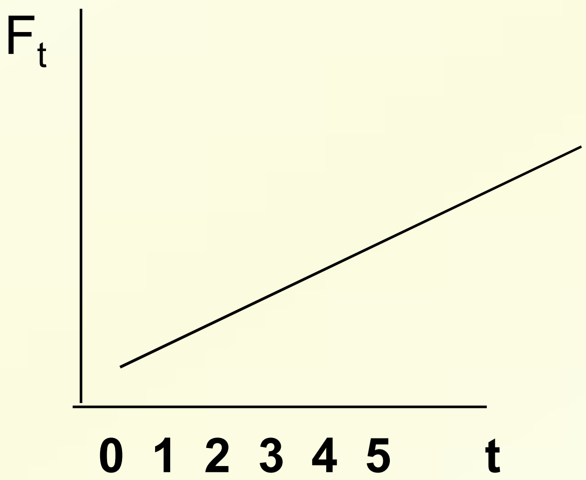
- Weighted averaging method based on previous forecast plus a percentage of the forecast error
- A-F is the error term, α is the % feedback

Picking a Smoothing Constant



Linear Trend Equation

$$F_t = a + bt$$



- F_t = Forecast for period t
- t = Specified number of time periods
- a = Value of F_t at t = 0
- b = Slope of the line

Calculating a and b

$$b = \frac{n \sum (ty) - \sum t \sum y}{n \sum t^2 - (\sum t)^2}$$

$$a = \frac{\sum y - b \sum t}{n}$$

Linear Trend Equation Example

t Week	t^2	y Sales	ty
1	1	150	150
2	4	157	314
3	9	162	486
4	16	166	664
5	25	177	885
$\Sigma t = 15$ $(\Sigma t)^2 = 225$	$\Sigma t^2 = 55$	$\Sigma y = 812$	$\Sigma ty = 2499$

Linear Trend Calculation

$$\mathbf{b = \frac{5\,(2499) - 15(812)}{5(55) - 225} = \frac{12495 - 12180}{275 - 225} = 6.3}$$

$$a = \frac{812 - 6.3(15)}{5} = \mathbf{143.5}$$

$$y = 143.5 + 6.3t$$

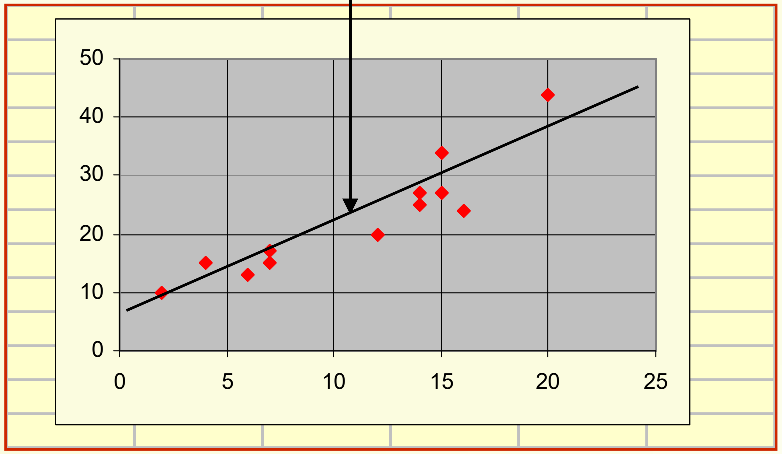
Associative Forecasting

- *Predictor variables* - used to predict values of variable interest
- *Regression* - technique for fitting a line to a set of points
- *Least squares line* - minimizes sum of squared deviations around the line

Linear Model Seems Reasonable

X	Y
7	15
2	10
6	13
4	15
14	25
15	27
16	24
12	20
14	27
20	44
15	34
7	17

Computed relationship



A straight line is fitted to a set of sample points.

Forecast Accuracy

- Error - difference between actual value and predicted value
- Mean Absolute Deviation (MAD)
  - Average absolute error
- Mean Squared Error (MSE)
  - Average of squared error
- Mean Absolute Percent Error (MAPE)
  - Average absolute percent error

MAD, MSE, and MAPE

$$MAD = \frac{\sum \left| Actual - forecast \right|}{n}$$

$$MSE = \frac{\sum (Actual - forecast)^2}{n - 1}$$

$$MAPE = \frac{\sum(\left| Actual_t - forecast_t \right| / Actual_t * 100)}{n}$$

Controlling the Forecast

- Control chart
  - A visual tool for monitoring forecast errors
  - Used to detect non-randomness in errors
- Forecasting errors are in control if
  - All errors are within the control limits
  - No patterns, such as trends or cycles, are present

Sources of Forecast errors

- Model may be inadequate
- Irregular variations
- Incorrect use of forecasting technique

Tracking Signal

- Tracking signal
  - Ratio of cumulative error to MAD

$$\text{Tracking signal} = \frac{\sum(\text{Actual-forecast})}{\text{MAD}}$$

Bias **– Persistent tendency for forecasts to be Greater or less than actual values.**

Choosing a Forecasting Technique

- No single technique works in every situation
- Two most important factors
  - Cost
  - Accuracy
- Other factors include the availability of:
  - Historical data
  - Computers
  - Time needed to gather and analyze the data
  - Forecast horizon

CHAPTER 3

Product and Service Design

McGraw-Hill/Irwin

Product and Service Design

- Major factors in design strategy
  - Cost
  - Quality
  - Time-to-market
  - Customer satisfaction
  - Competitive advantage

Product and service design – or redesign – should be closely tied to an organization's strategy

Product or Service Design Activities

- Translate customer wants and needs into product and service requirements
- Refine existing products and services
- Develop new products and services
- Formulate quality goals
- Formulate cost targets
- Construct and test prototypes
- Document specifications

Reasons for Product or Service Design

- Economic
- Social and demographic
- Political, liability, or legal
- Competitive
- Technological

Objectives of Product and Service Design

- Main focus
  - Customer satisfaction
- Secondary focus
  - Function of product/service
  - Cost/profit
  - Quality
  - Appearance
  - Ease of production/assembly
  - Ease of maintenance/service

Designing For Operations

- Taking into account the capabilities of the organization in designing goods and services

Legal, Ethical, and Environmental Issues

- Legal
  - FDA, OSHA, IRS
  - Product liability
  - Uniform commercial code
- Ethical
  - Releasing products with defects
- Environmental
  - EPA

Regulations & Legal Considerations

- *Product Liability* - A manufacturer is liable for any injuries or damages caused by a faulty product.
- *Uniform Commercial Code* - Products carry an implication of merchantability and fitness.

Designers Adhere to Guidelines

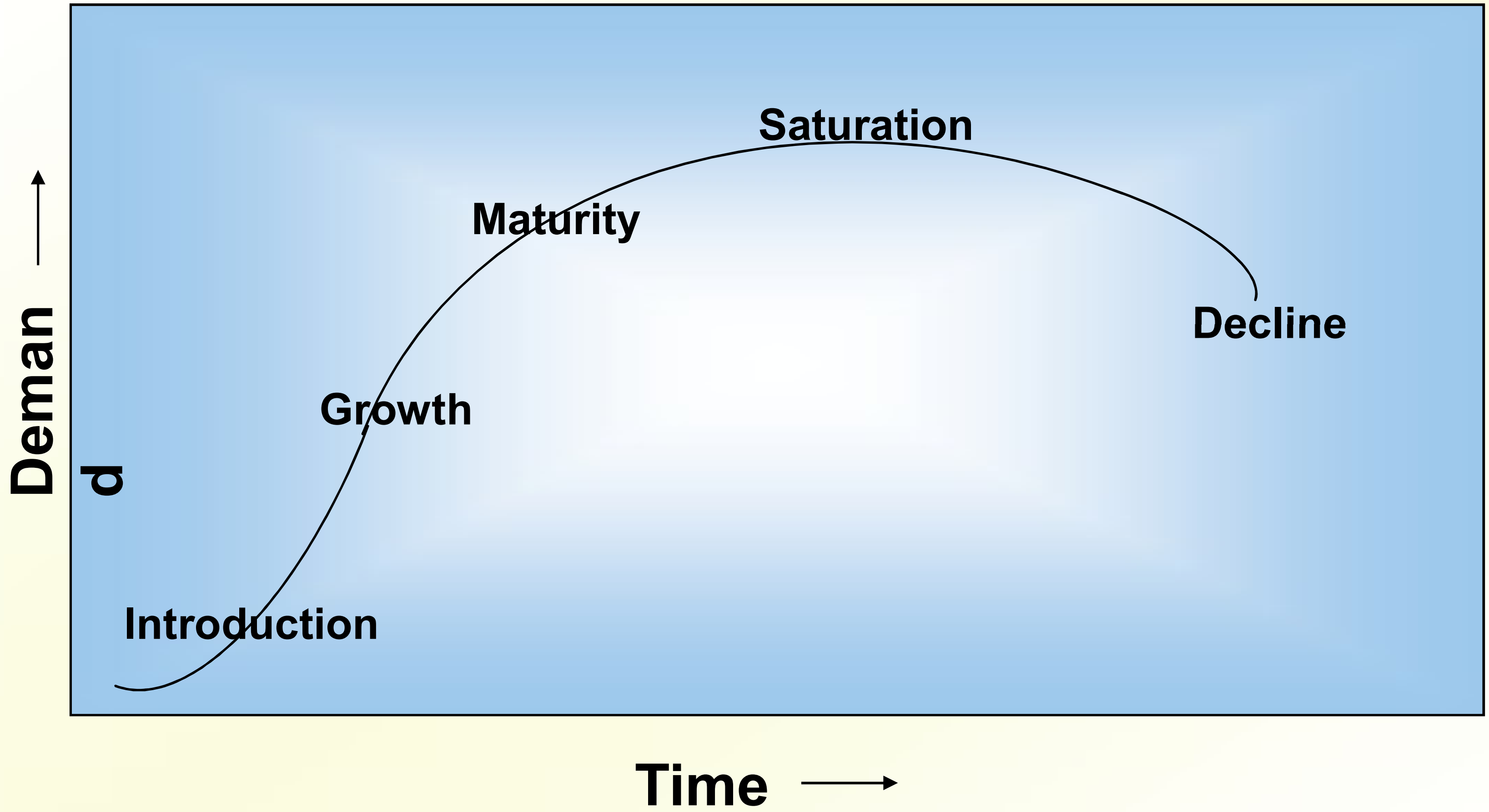
- Produce designs that are consistant with the goals of the company
- Give customers the value they expect
- Make health and safety a primary concern
- Consider potential harm to the environment

Other Issues in Product and Service Design

- Product/service life cycles
- How much standardization
- Product/service reliability
- Range of operating conditions

Life Cycles of Products or Services

Figure 4.1



Standardization

- Standardization
  - Extent to which there is an absence of variety in a product, service or process
- Standardized products are immediately available to customers

Advantages of Standardization

- Fewer parts to deal with in inventory & manufacturing
- Design costs are generally lower
- Reduced training costs and time
- More routine purchasing, handling, and inspection procedures

Advantages of Standardization (Cont'd)

- Orders fillable from inventory
- Opportunities for long production runs and automation
- Need for fewer parts justifies increased expenditures on perfecting designs and improving quality control procedures.

Disadvantages of Standardization

- Designs may be frozen with too many imperfections remaining.
- High cost of design changes increases resistance to improvements.
- Decreased variety results in less consumer appeal.

Mass Customization

- Mass customization:
  - A strategy of producing standardized goods or services, but incorporating some degree degree of customization
  - Delayed differentiation
  - Modular design

Delayed Differentiation

- Delayed differentiation is a postponement tactic
  - Producing but not quite completing a product or service until customer preferences or specifications are known

Modular Design

Modular design is a form of standardization in which component parts are subdivided into modules that are easily replaced or interchanged. It allows:

- easier diagnosis and remedy of failures
- easier repair and replacement
- simplification of manufacturing and assembly

Reliability

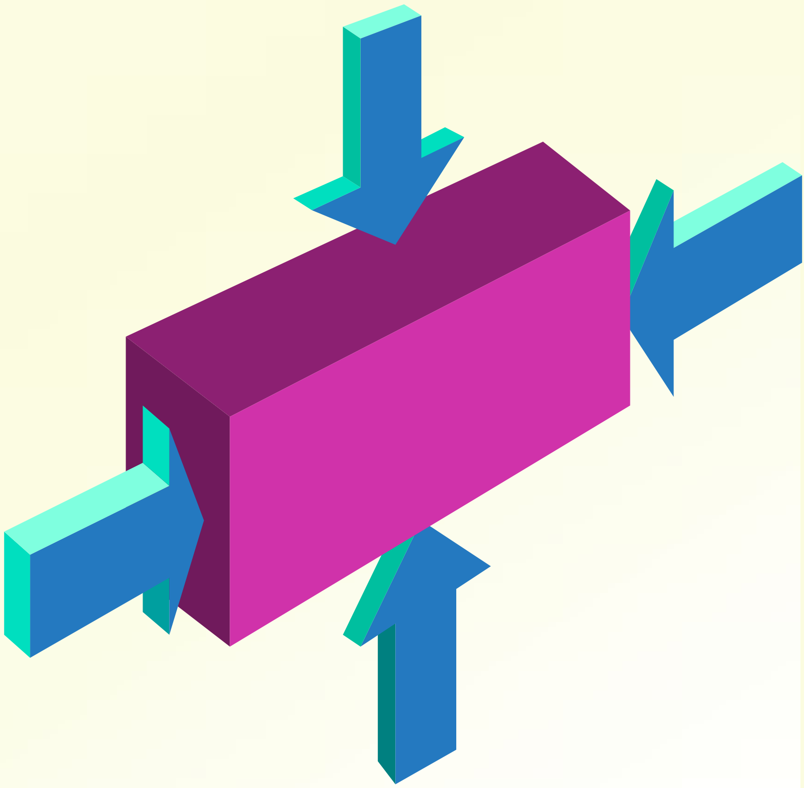
- ***Reliability***: The ability of a product, part, or system to perform its intended function under a prescribed set of conditions
- ***Failure***: Situation in which a product, part, or system does not perform as intended
- ***Normal operating conditions***: The set of conditions under which an item's reliability is specified

Improving Reliability

- Component design
- Production/assembly techniques
- Testing
- Redundancy/backup
- Preventive maintenance procedures
- User education
- System design

Product Design

- Product Life Cycles
- Robust Design
- Concurrent Engineering
- Computer-Aided Design
- Modular Design



Robust Design

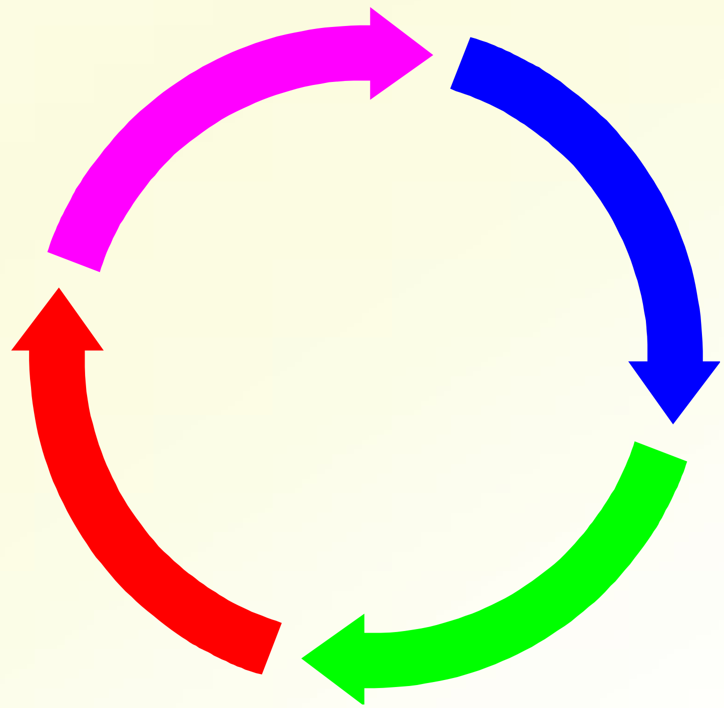
Robust Design: Design that results in products or services that can function over a broad range of conditions

Degree of Newness

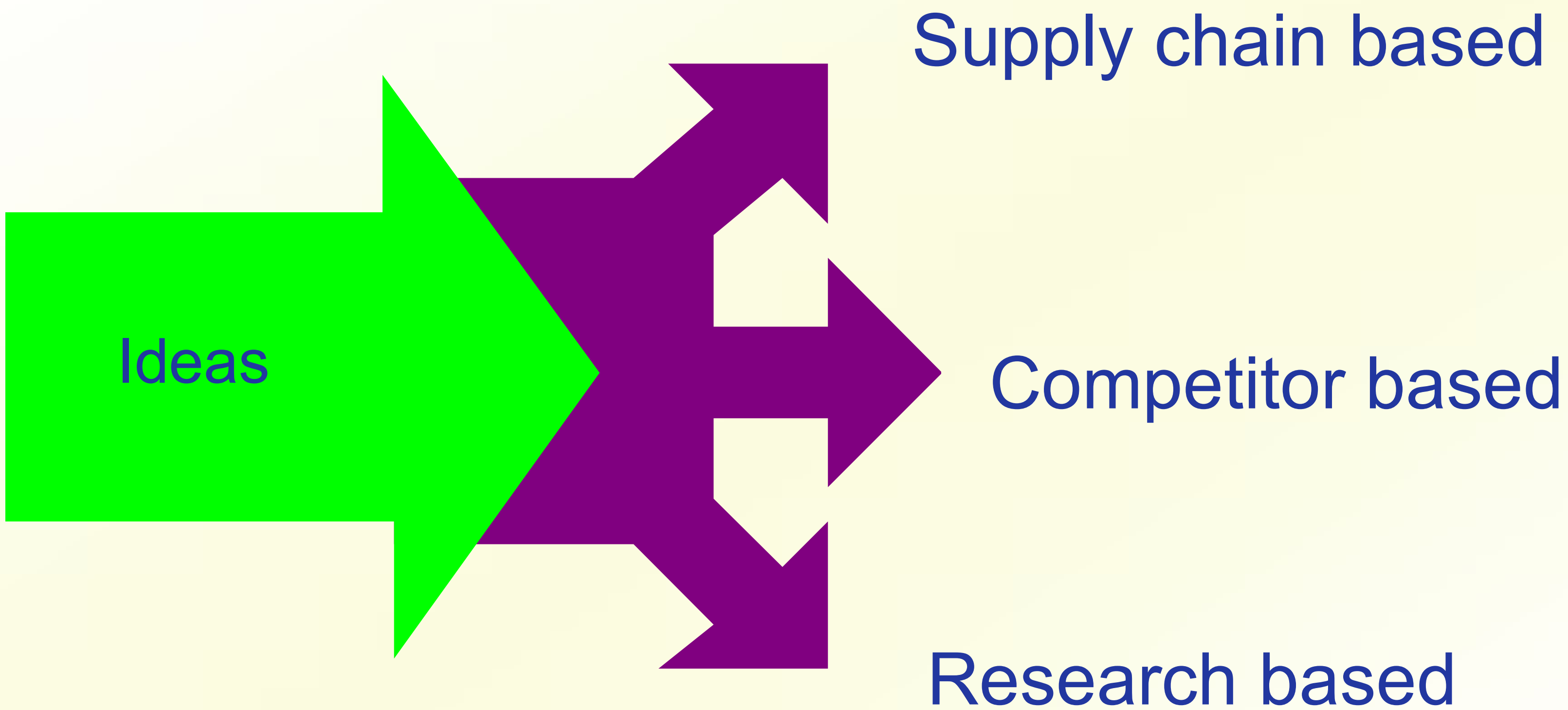
1. Modification of an existing product/service
2. Expansion of an existing product/service
3. Clone of a competitor's product/service
4. New product/service

Phases in Product Development Process

1. Idea generation
2. Feasibility analysis
3. Product specifications
4. Process specifications
5. Prototype development
6. Design review
7. Market test
8. Product introduction
9. Follow-up evaluation



Idea Generation



Reverse Engineering

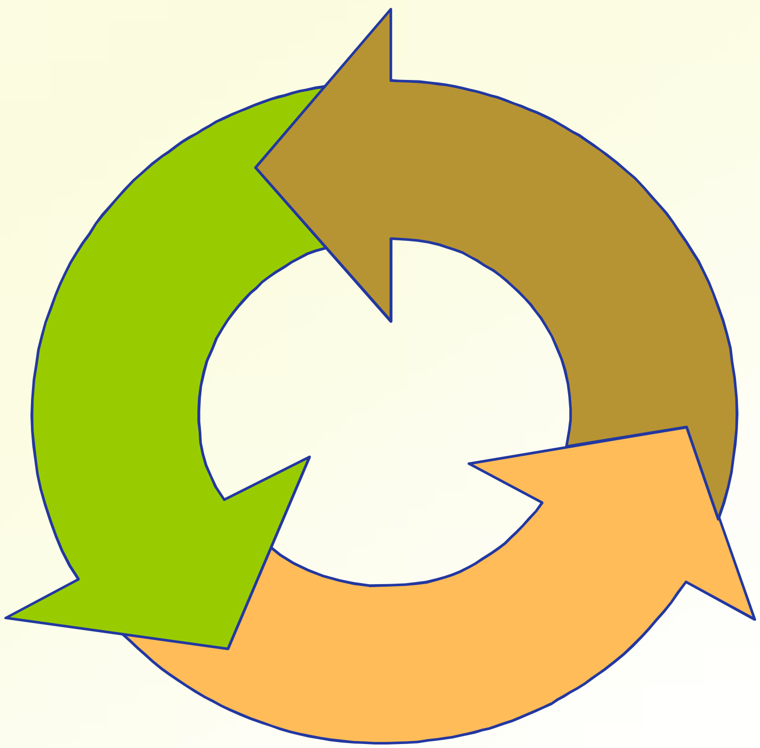
Reverse engineering **is the dismantling and inspecting of a competitor's product to discover product improvements.**

Research & Development (R&D)

- Organized efforts to increase scientific knowledge or product innovation & may involve:
  - *Basic Research* advances knowledge about a subject without near-term expectations of commercial applications.
  - *Applied Research* achieves commercial applications.
  - *Development* converts results of applied research into commercial applications.

Manufacturability

- Manufacturability **is the ease of fabrication and/or assembly which is important for:**
  - Cost
  - Productivity
  - Quality



Concurrent Engineering

Concurrent engineering
is the bringing together of engineering design and manufacturing personnel early in the design phase.

Computer-Aided Design

- *Computer-Aided Design (CAD)* is product design using computer graphics.
  - increases productivity of designers, 3 to 10 times
  - creates a database for manufacturing information on product specifications
  - provides possibility of engineering and cost analysis on proposed designs

Recycling

- Recycling: recovering materials for future use
- Recycling reasons
  - Cost savings
  - Environment concerns
  - Environment regulations

Service Design

- Service is an act
- Service delivery system
  - Facilities
  - Processes
  - Skills
- Many services are bundled with products

Service Design

- Service design involves
  - The physical resources needed
  - The goods that are purchased or consumed by the customer
  - Explicit services
  - Implicit services

Service Design

- Service
  - Something that is done to or for a customer
- Service delivery system
  - The facilities, processes, and skills needed to provide a service
- Product bundle
  - The combination of goods and services provided to a customer
- Service package
  - The physical resources needed to perform the service

Differences Between Product and Service Design

- Tangible – intangible
- Services created and delivered at the same time
- Services cannot be inventoried
- Services highly visible to customers
- Services have low barrier to entry
- Location important to service

Phases in Service Design

1. Conceptualize
2. Identify service package components
3. Determine performance specifications
4. Translate performance specifications into design specifications
5. Translate design specifications into delivery specifications

Service Blueprinting

- Service blueprinting
  - A method used in service design to describe and analyze a proposed service
- A useful tool for conceptualizing a service delivery system

Major Steps in Service Blueprinting

1. Establish boundaries
2. Identify steps involved
3. Prepare a flowchart
4. Identify potential failure points
5. Establish a time frame
6. Analyze profitability

Characteristics of Well Designed Service Systems

1. Consistent with the organization mission
2. User friendly
3. Robust
4. Easy to sustain
5. Cost effective
6. Value to customers
7. Effective linkages between back operations
8. Single unifying theme
9. Ensure reliability and high quality

Challenges of Service Design

- Variable requirements
- Difficult to describe
- High customer contact
- Service – customer encounter

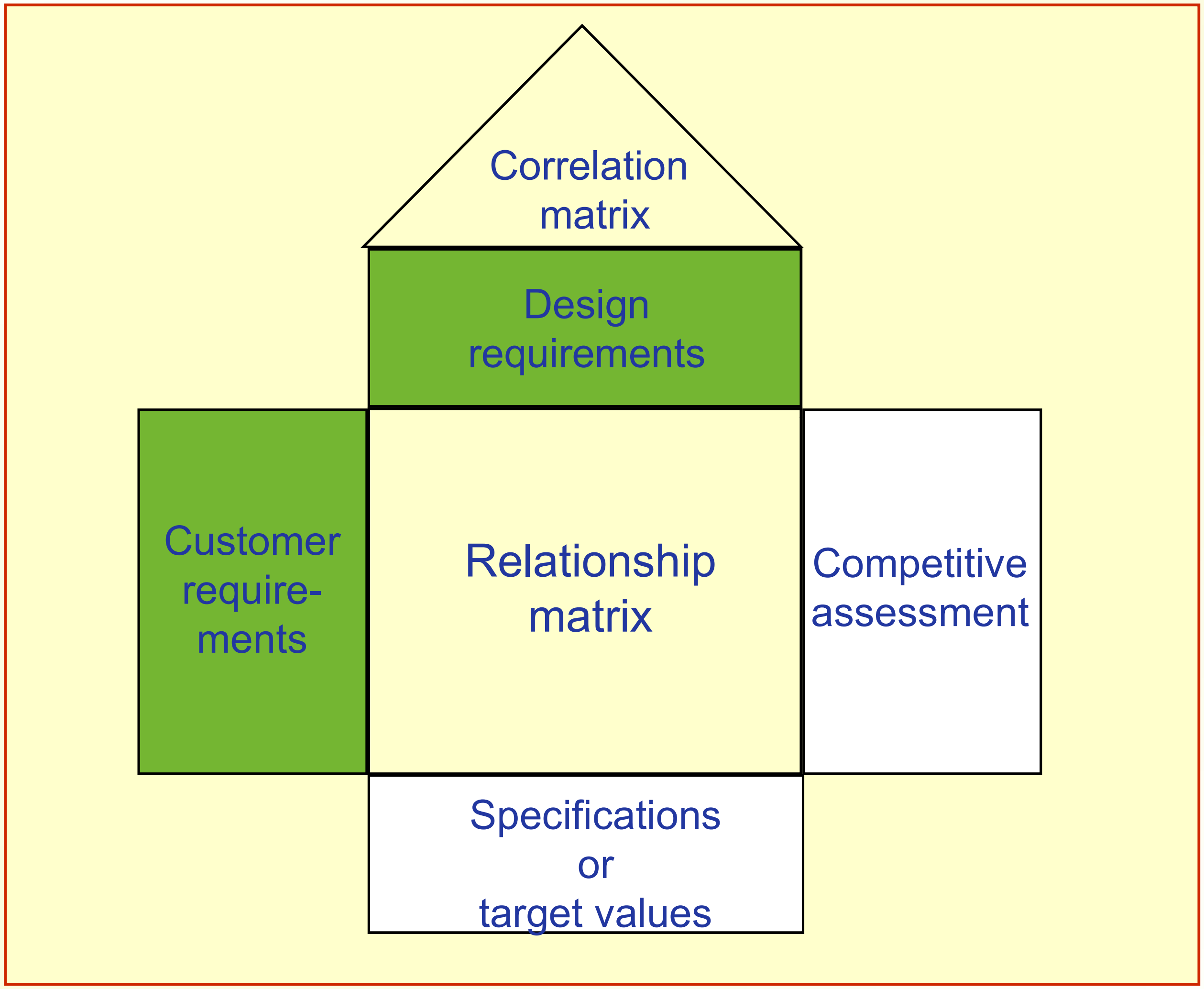
Quality Function Deployment

- Quality Function Deployment
  - Voice of the customer
  - House of quality

QFD: An approach that integrates the "voice of the customer" into the product and service development process.

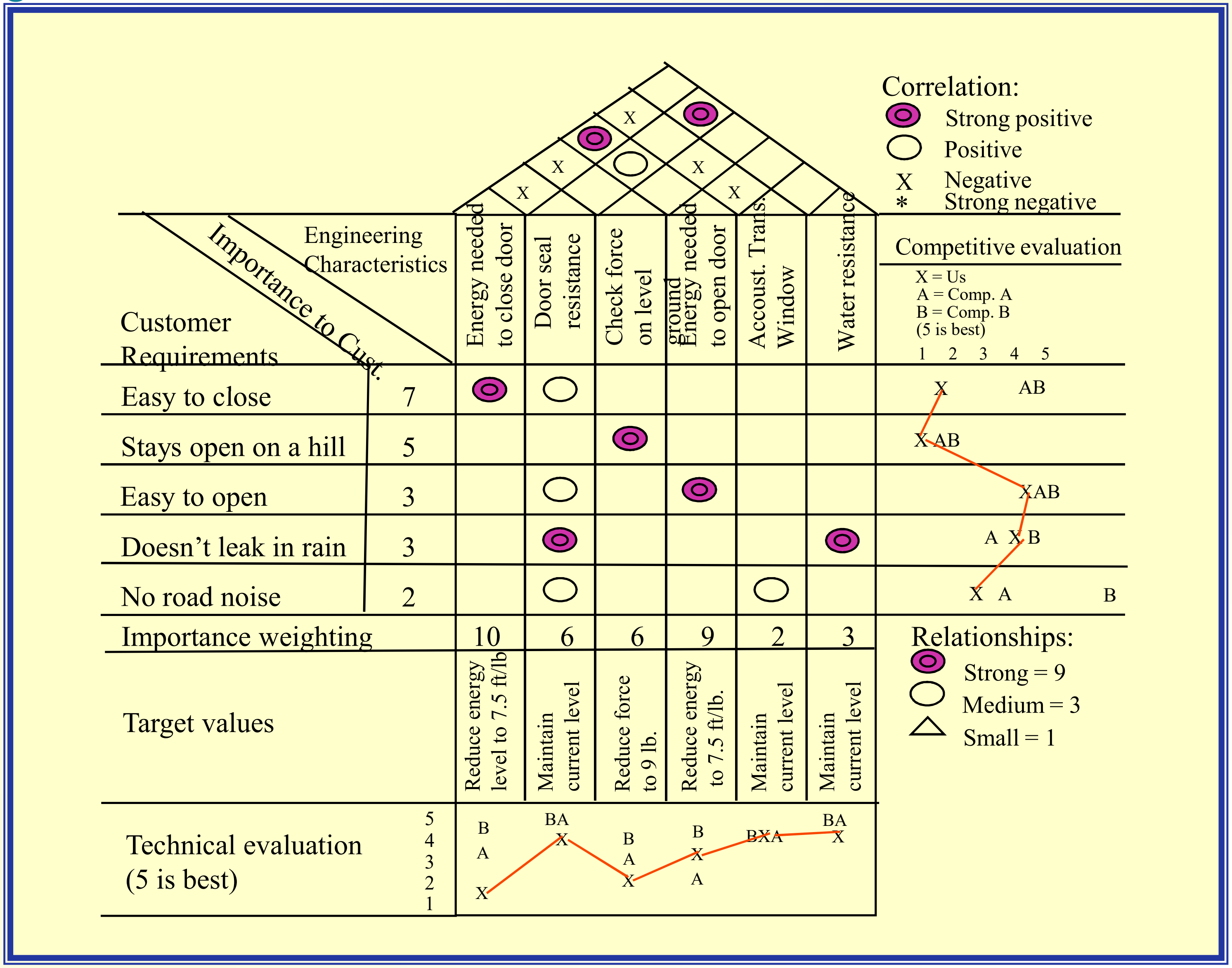
The House of Quality

Figure 4.4



House of Quality Example

Figure 4.5



Operations Strategy

1. Increase emphasis on component commonality
2. Package products and services
3. Use multiple-use platforms
4. Consider tactics for mass customization
5. Look for continual improvement
6. Shorten time to market

Shorten Time to Market

1. Use standardized components
2. Use technology
3. Use concurrent engineering

CHAPTER
4

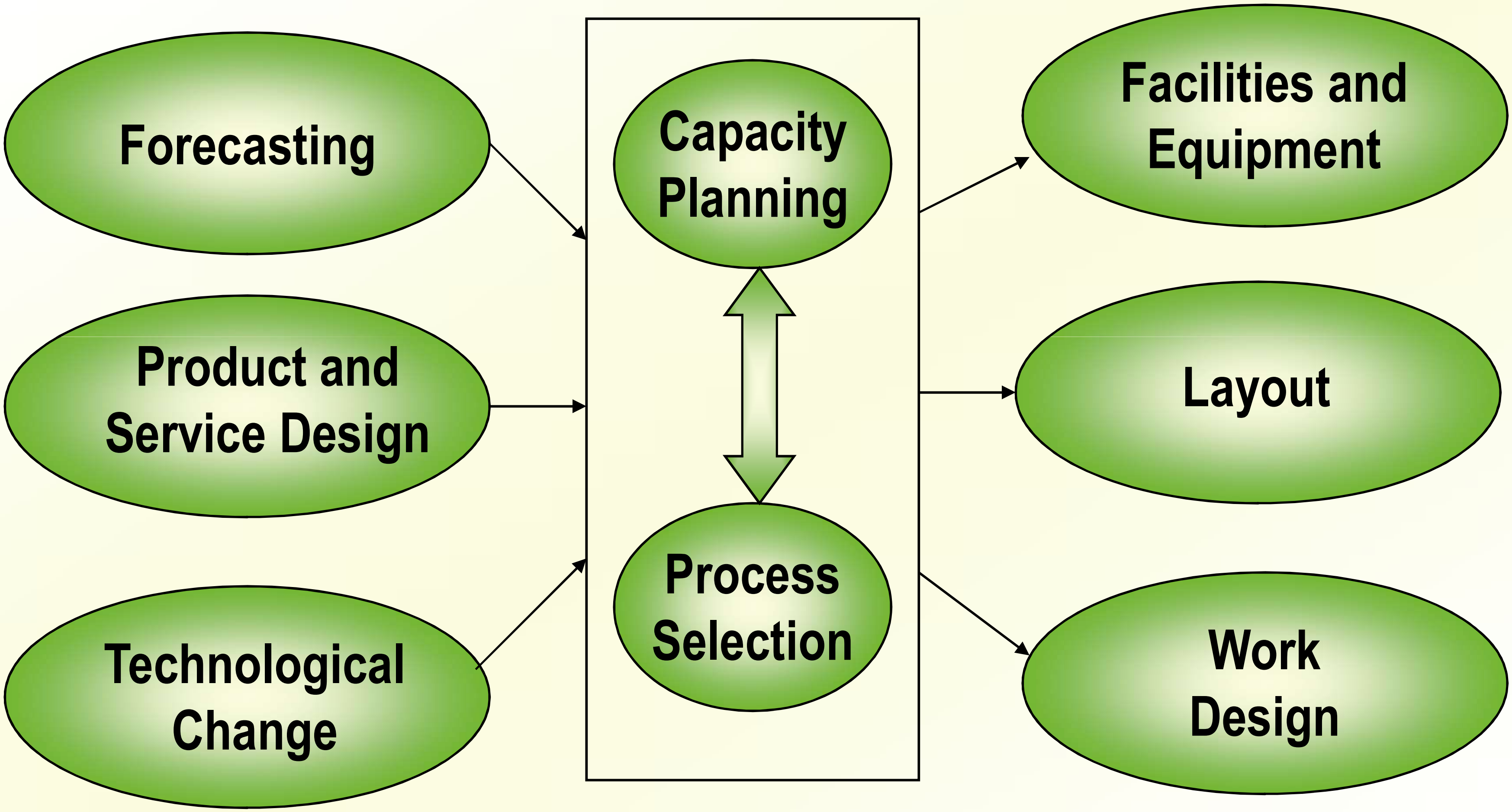
Process Selection and Facility Layout

Introduction

- Process selection
  - Deciding on the way production of goods or services will be organized
- Major implications
  - Capacity planning
  - Layout of facilities
  - Equipment
  - Design of work systems

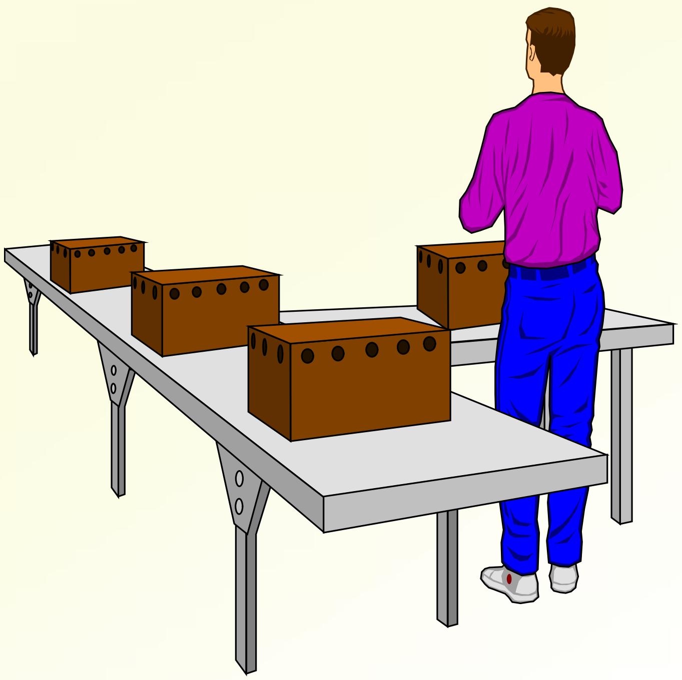
Process Selection and System Design

Figure 6.1



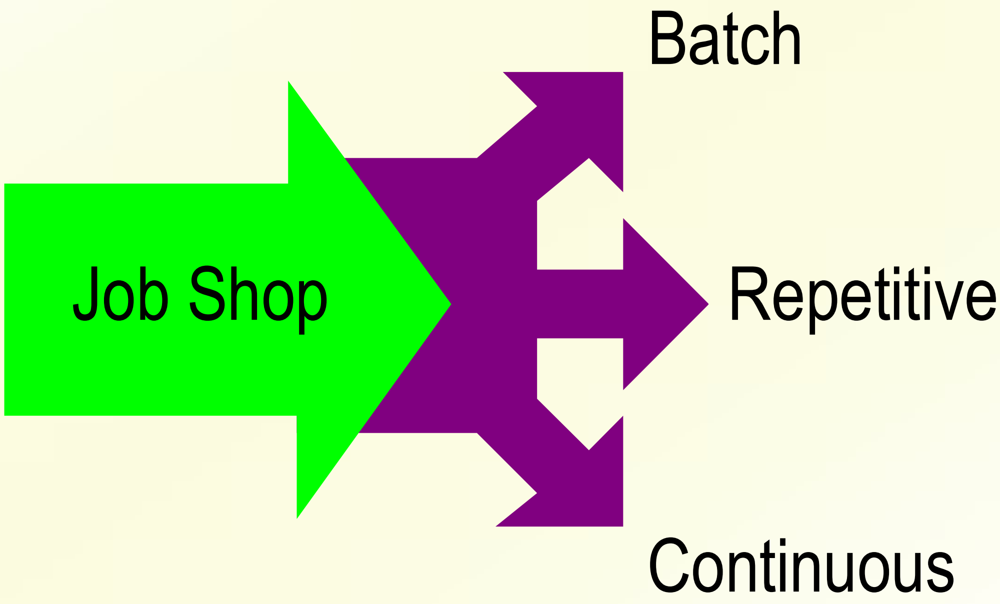
Process Strategy

- Key aspects of process strategy
  - Capital intensive – equipment/labor
  - Process flexibility
  - Adjust to changes
    - Design
    - Volume
    - technology



Process Selection

- Variety
  - How much
- Flexibility
  - What degree
- Volume
  - Expected output



Process Types

- Job shop
  - Small scale
- Batch
  - Moderate volume
- Repetitive/assembly line
  - High volumes of standardized goods or services
- Continuous
  - Very high volumes of non-discrete goods

Product – Process Matrix

Figure 6.2

Process Type				
Job Shop	Appliance repair Emergency room			Not feasible
Batch		Commercial bakery Classroom Lecture		
Repetitive			Automotive assembly Automatic carwash	
Continuous (flow)	Not feasible			Oil refinery Water purification

Product – Process Matrix

Figure 6.2 (cont'd)

Dimension				
Job variety	Very High	Moderate	Low	Very low
Process flexibility	Very High	Moderate	Low	Very low
Unit cost	Very High	Moderate	Low	Very low
Volume of output	Very High	Low	High	Very low

Automation

- ***Automation***: Machinery that has sensing and control devices that enables it to operate
  - Fixed automation
  - Programmable automation

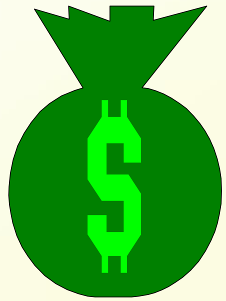
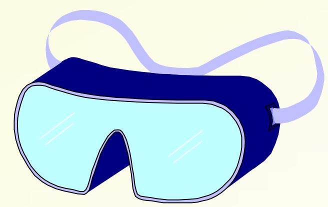
Facilities Layout

- *Layout*: the configuration of departments, work centers, and equipment, with particular emphasis on movement of work (customers or materials) through the system

Importance of Layout Decisions

- Requires substantial investments of money and effort
- Involves long-term commitments
- Has significant impact on cost and efficiency of short-term operations

The Need for Layout Decisions

Inefficient operations For Example: High Cost Bottlenecks 	Changes in the design of products or services
The introduction of new products or services	Accidents  Safety hazards

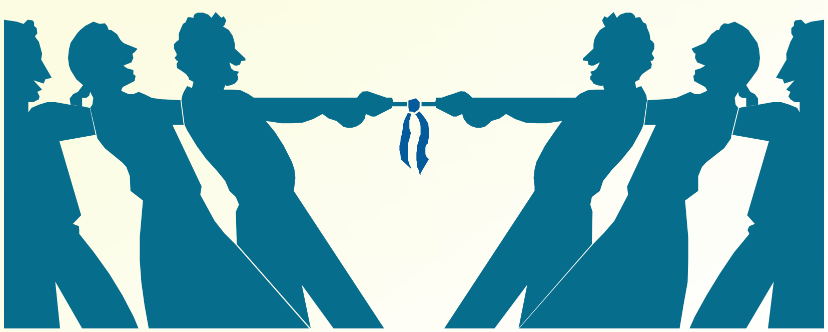
The Need for Layout Design (Cont'd)

Changes in environmental or other legal requirements

Changes in volume of output or mix of products

Changes in methods and equipment

Morale problems



Basic Layout Types

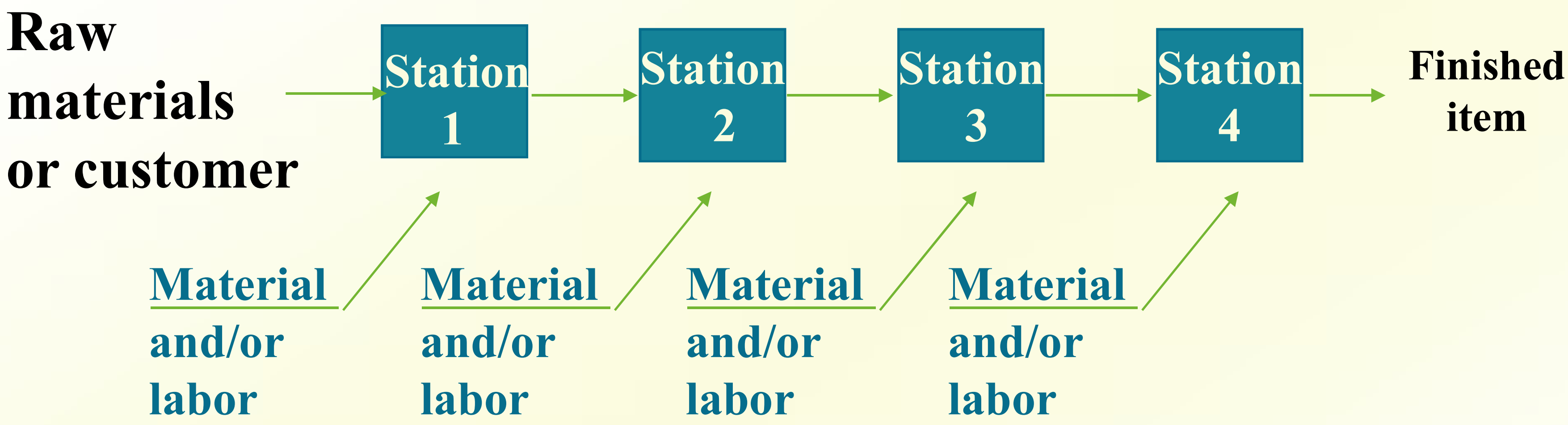
- Product layouts
- Process layouts
- Fixed-Position layout
- Combination layouts

Basic Layout Types

- Product layout
  - Layout that uses standardized processing operations to achieve smooth, rapid, high-volume flow
- Process layout
  - Layout that can handle varied processing requirements
- Fixed Position layout
  - Layout in which the product or project remains stationary, and workers, materials, and equipment are moved as needed

Product Layout

Figure 6.4



Used for Repetitive or Continuous Processing

Advantages of Product Layout

- High rate of output
- Low unit cost
- Labor specialization
- Low material handling cost
- High utilization of labor and equipment
- Established routing and scheduling
- Routing accounting and purchasing

Disadvantages of Product Layout

- Creates dull, repetitive jobs
- Poorly skilled workers may not maintain equipment or quality of output
- Fairly inflexible to changes in volume
- Highly susceptible to shutdowns
- Needs preventive maintenance
- Individual incentive plans are impractical

Process Layout

Figure 6.7

Process Layout
(functional)

Dept. A	Dept. C	Dept. E
Dept. B	Dept. D	Dept. F

Used for Intermittent processing
Job Shop or Batch

Product Layout

Figure 6.7 (cont'd)

Product Layout
(sequential)

Work Station 1 → **Work Station 2** → **Work Station 3**

Used for Repetitive Processing
Repetitive or Continuous

Advantages of Process Layouts

- Can handle a variety of processing requirements
- Not particularly vulnerable to equipment failures
- Equipment used is less costly
- Possible to use individual incentive plans

Disadvantages of Process Layouts

- In-process inventory costs can be high
- Challenging routing and scheduling
- Equipment utilization rates are low
- Material handling slow and inefficient
- Complexities often reduce span of supervision
- Special attention for each product or customer
- Accounting and purchasing are more involved

Cellular Layouts

- Cellular Production
  - Layout in which machines are grouped into a cell that can process items that have similar processing requirements
- Group Technology
  - The grouping into part families of items with similar design or manufacturing characteristics

Other Service Layouts

- Warehouse and storage layouts
- Retail layouts
- Office layouts

Design Product Layouts: Line Balancing

Line Balancing is the process of assigning tasks to workstations in such a way that the workstations have approximately equal time requirements.

Cycle Time

Cycle time is the maximum time allowed at each workstation to complete its set of tasks on a unit.

Determine Maximum Output

$$\text{Output capacity} = \frac{OT}{CT}$$

OT = operating time per day

D = Desired output rate

$$CT = \text{cycle time} = \frac{OT}{D}$$

Determine the Minimum Number of Workstations Required

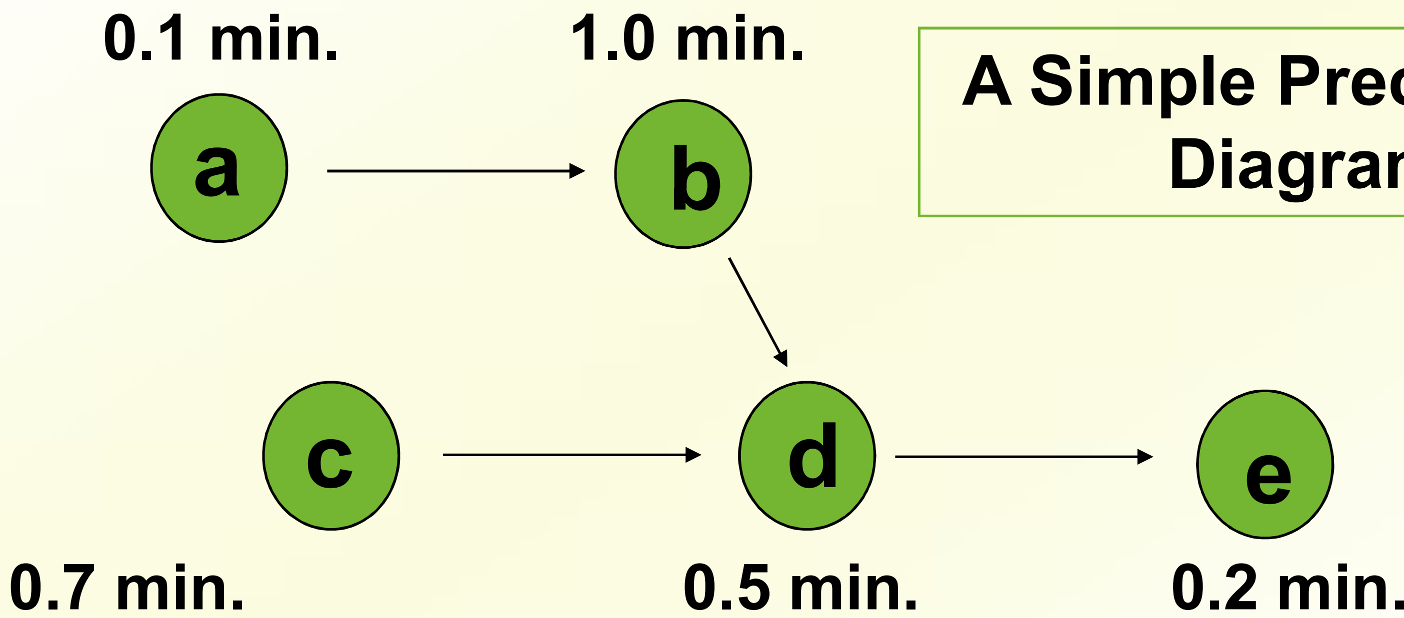
$$N = \frac{(D)(\sum t)}{OT}$$

$$\sum t = \text{sum of task times}$$

Precedence Diagram

Figure 6.10

Precedence diagram: Tool used in line balancing to display elemental tasks and sequence requirements



A Simple Precedence Diagram

Calculate Percent Idle Time

$$\text{Percent idle time} = \frac{\text{Idle time per cycle}}{(N)(CT)}$$

Efficiency = 1 – Percent idle time

Line Balancing Rules

Some Heuristic (intuitive) Rules:

- Assign tasks in order of most following tasks.
  - Count the number of tasks that follow
- Assign tasks in order of greatest positional weight.
  - Positional weight is the sum of each task’s time and the times of all following tasks.

Designing Process Layouts

Information Requirements:

1. List of departments
2. Projection of work flows
3. Distance between locations
4. Amount of money to be invested
5. List of special considerations
6. Location of key utilities

CHAPTER
5

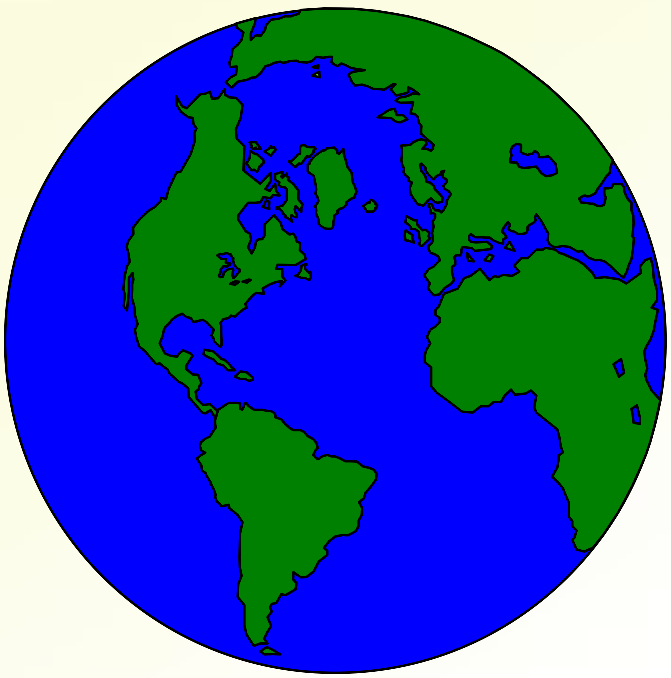
Location Planning and Analysis

McGraw-Hill/Irwin

Operations Management, Eighth Edition, by William J. Stevenson

Need for Location Decisions

- Marketing Strategy
- Cost of Doing Business
- Growth
- Depletion of Resources



Nature of Location Decisions

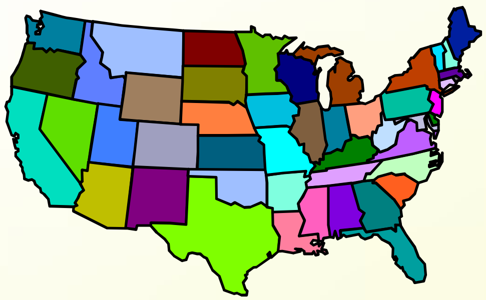
- Strategic Importance
  - Long term commitment/costs
  - Impact on investments, revenues, and operations
  - Supply chains
- Objectives
  - Profit potential
  - No single location may be better than others
  - Identify several locations from which to choose
- Options
  - Expand existing facilities
  - Add new facilities
  - Move

Making Location Decisions

- Decide on the criteria
- Identify the important factors
- Develop location alternatives
- Evaluate the alternatives
- Make selection

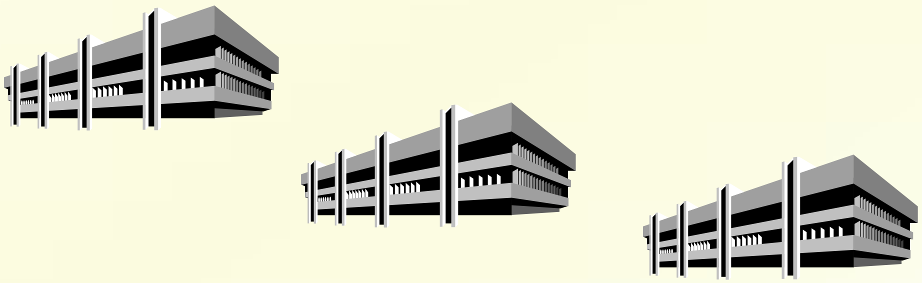
Location Decision Factors

Regional Factors

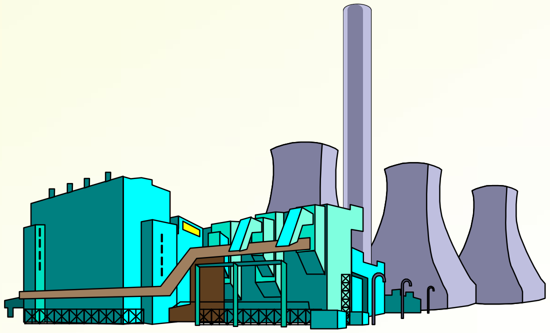


Community Considerations

Multiple Plant Strategies

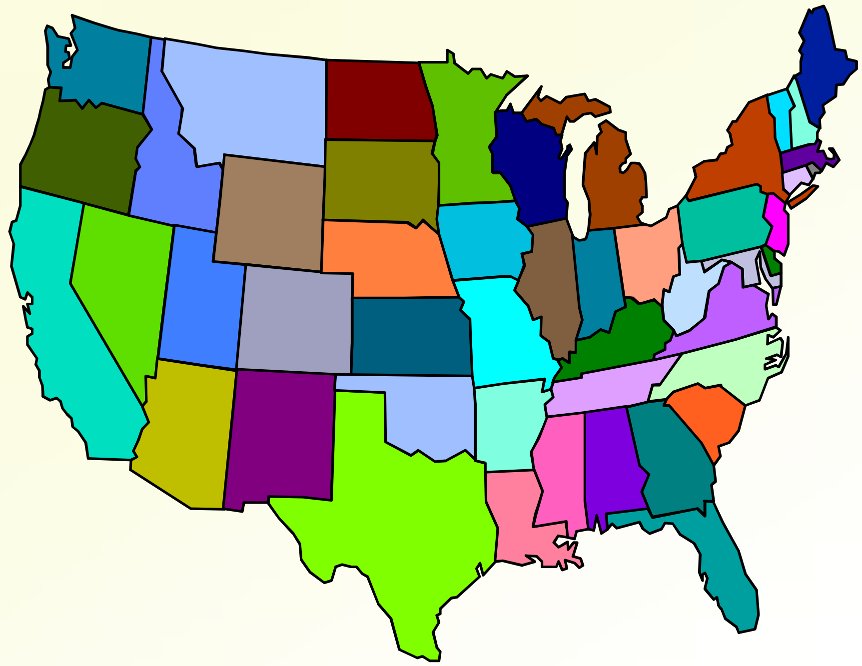


Site-related Factors



Regional Factors

- Location of raw materials
- Location of markets
- Labor factors
- Climate and taxes

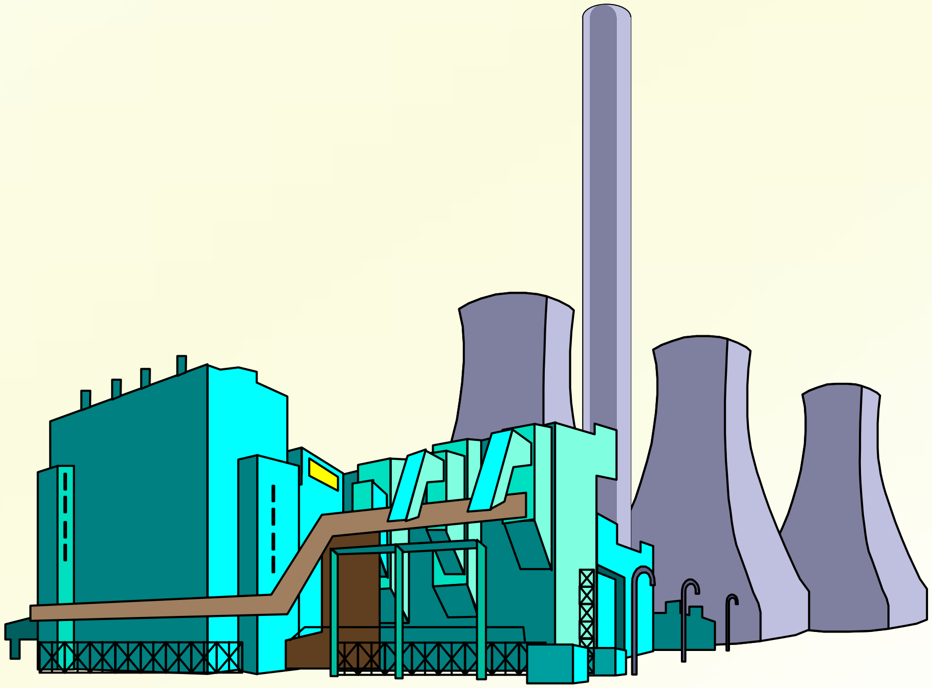


Community Considerations

- Quality of life
- Services
- Attitudes
- Taxes
- Environmental regulations
- Utilities
- Developer support

Site Related Factors

- Land
- Transportation
- Environmental
- Legal



Multiple Plant Strategies

- Product plant strategy
- Market area plant strategy
- Process plant strategy

Comparison of Service and Manufacturing Considerations

Table 8.2

Manufacturing/Distribution	Service/Retail
Cost Focus	**Revenue focus**
Transportation modes/costs	Demographics: age,income,etc
Energy availability, costs	Population/drawing area
Labor cost/availability/skills	Competition
Building/leasing costs	Traffic volume/patterns
	Customer access/parking

Trends in Locations

- Foreign producers locating in U.S.
  - “Made in USA”
  - Currency fluctuations
- Just-in-time manufacturing techniques
- Microfactories
- Information Technology

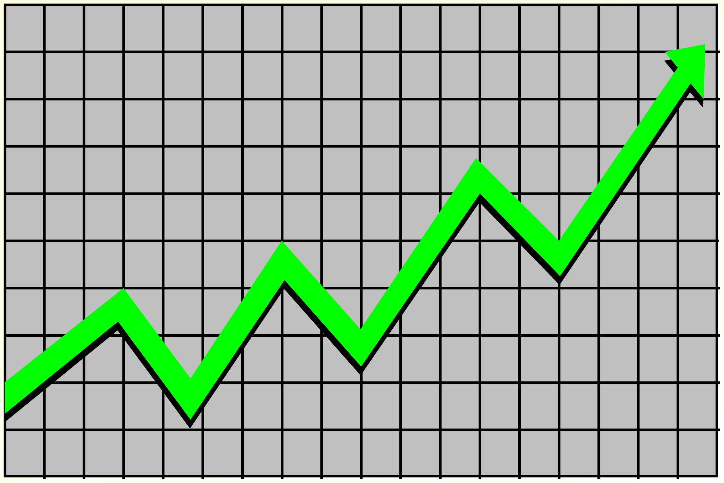
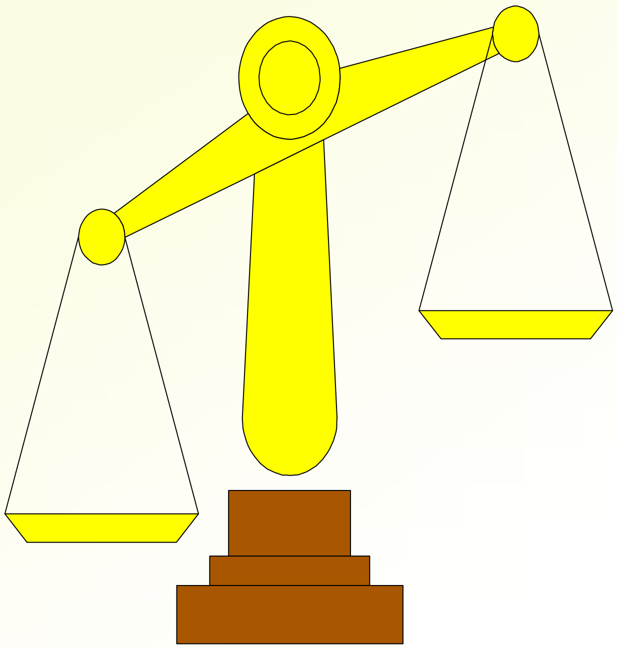


Table 8.3

Foreign Government	a. Policies on foreign ownership of production facilities Local Content Import restrictions Currency restrictions Environmental regulations Local product standards b. Stability issues
Cultural Differences	Living circumstances for foreign workers / dependents Religious holidays/traditions
Customer Preferences	Possible buy locally sentiment
Labor	Level of training and education of workers Work practices Possible regulations limiting number of foreign employees Language differences
Resources	Availability and quality of raw materials, energy, transportation

Evaluating Locations

- Cost-Profit-Volume Analysis
  - Determine fixed and variable costs
  - Plot total costs
  - Determine lowest total costs



Location Cost-Volume Analysis

- Assumptions
  - Fixed costs are constant
  - Variable costs are linear
  - Output can be closely estimated
  - Only one product involved

Example 1: Cost-Volume Analysis

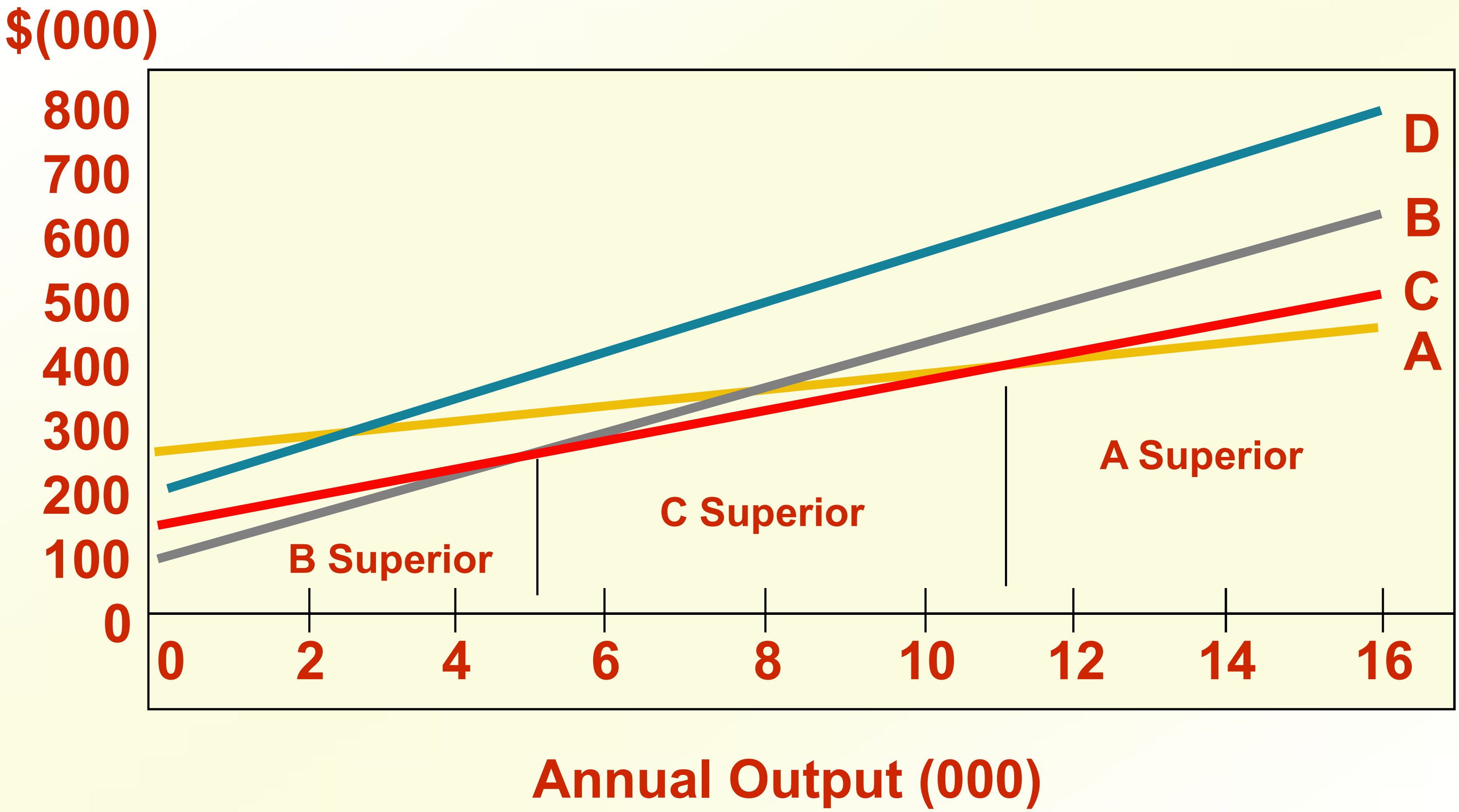
Fixed and variable costs for four potential locations

Location	Fixed Cost	Variable Cost
A	$250,000	$11
B	100,000	30
C	150,000	20
D	200,000	35

Example 1: Solution

	Fixed Costs	Variable Costs	Total Costs
A	$250,000	$11(10,000)	$360,000
B	100,000	30(10,000)	400,000
C	150,000	20(10,000)	350,000
D	200,000	35(10,000)	550,000

Example 1: Solution



Evaluating Locations

- Transportation Model
  - Decision based on movement costs of raw materials or finished goods
- Factor Rating
  - Decision based on quantitative and qualitative inputs
- Center of Gravity Method
  - Decision based on minimum distribution costs

Chapter 7

- Another one chapter will be there in the first unit and we will discuss it following text books.

Thank You